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# Irrigation on the Blood Indian Reserve: A Feasibility Study

# Summary Report

The cover of this report features the work of Marilyn King, 28, of the Blood Indian Reserve. Although she has no formal art school training, she has always been interested in art, and with the encouragement of her husband, she has continued to develop her skills. Much of her work depicts native Indian themes, including this untitled piece which portrays the historical value of water to the Indians as a source of life, and its modern value as irrigation brings new life to their land, and modernization and prosperity to their people.

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# IRRIGATION
ON THE
# BLOOD INDIAN RESERVE
# — A FEASIBILTY STUDY —

## SUMMARY REPORT

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BLOOD INDIAN IRRIGATION
TRIPARTITE COMMITTEE

BLOOD INDIAN TRIBE — ALBERTA, CANADA
FEBRUARY 1983

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# Letter of Transmittal

Chief Roy J. Fox, Chief, Blood Tribal Administration, Standoff

The Hon. Fred D. Bradley, Minister of Environment, Edmonton

The Hon. E. Leroy Fjordbotten, Minister of Agriculture, Edmonton

The Hon. Milt G. Pahl, Minister Responsible for Native Affairs, Edmonton

The Hon. Jim D. Horsman, Minister of Federal and Intergovernmental Affairs, Edmonton

The Hon. John C. Munro, Minister of Indian Affairs and Northern Development, Ottawa

The Hon. Eugene F. Whelan, Minister of Agriculture, Ottawa

Dear Sirs:

In February, 1980 the Chief of the Blood Indian Tribe and the Alberta Ministers of Environment, Agriculture, Native Affairs and Federal and Intergovernmental Affairs recommended establishment of a committee to determine the feasibility of developing irrigation in the northeastern area of the Blood Indian Reserve. Representatives of federal departments of Indian Affairs and Northern Development and Regional Economic Expansion were invited to participate. A tripartite committee was formed with representatives from the Blood Tribe and the various federal and provincial departments. The committee members are listed in Appendix B of this report. In addressing its assignment, the committee carried out a comprehensive feasibility study.

On behalf of the committee, we are pleased to present the findings of the study in this summary report. A complete summary of findings and recommendations is presented in Chapter IX of this report. The report includes an implementation chapter (Chapter X) which suggests administrative and financial arrangements for implementing the project. Eight supplements, bound separately, provide detailed information on various component studies.

The committee concludes that irrigating 25,000 acres of land in the northeastern area of the reserve is feasible considering technical, economic, environmental, social and administrative factors. Implementation of the project could be a positive step toward the betterment of social and economic conditions on the reserve.

Respectfully submitted,

Peter Melnychuk

Peter G. Melnychuk, Chairman

Bernard Fox

Bernard Fox, Co-Chairman

# Acknowledgements

The tripartite committee acknowledges the assistance and co-operation of all individuals and agencies who contributed to this feasibility study. A list of technical advisors and consultants involved in the study is provided in Appendix B. Because the study was interdisciplinary, co-operation among consultants and component leaders was particularly important to maintain the schedule and budget. The co-operation received was outstanding, for which the tripartite committee is grateful.

Special thanks are extended to Steve Mistaken Chief and Camille Russell, members of the Blood Tribe, who worked many long days providing liaison between study personnel and tribe members. Their efforts contributed to the successful completion of many of the study components and, hence, to the overall study.

The assistance and co-operation of the Blood Tribal Council and its administration throughout the study was much appreciated and is gratefully acknowledged.

Olive Bousquet acted as recording secretary for the tripartite committee. The summary report was drafted by Dick Hart and Doug Bouey. Dila Musa provided typing services for several draft reports, Manwell Da Silva co-ordinated the drafting, and Elaine Dixson co-ordinated the layout and printing. The tripartite committee appreciated and gratefully acknowledges the contributions of these individuals.

Photographs in this report were provided by Alberta Agriculture, Alberta Environment, PFRA and the Blood Tribal Administration.

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# CHAPTER I: INTRODUCTION

*Since 1952, the St. Mary Dam and reservoir, built partially on reserve land, have provided water for irrigation and other uses in southern Alberta.*

## A. Physical, Social and Economic Setting on the Reserve

The Blood Indian Reserve is a dominant feature of the southwestern portion of the province of Alberta (Figure 1), occupying some 510 square miles of the region bounded by the Belly, Oldman and St. Mary rivers in the west, north, and east, and the township line passing through Cardston in the south. The topography of the reserve includes foothills, grasslands, prairie buttes and farmland in its expanse. An irrigation canal taking water from the Belly River to the St. Mary Reservoir bisects the southern part of the reserve.

There are 5,800 members of the Blood Indian Tribe, 4,300 of whom live on the reserve. A startling 54 percent of the on-reserve population is under 20 years of age. The members live either in individual houses scattered over the countryside or in one of the communities of Standoff, Moses Lake, or Lavern, many in crowded or inadequate accomodations. The employment level is low — nearly 50 percent of the available labor force of 1,670 is unemployed. The average per capita income on the reserve is approximately half of the average for Canada. The chief sources of income on the reserve are, in order of descending magnitude, transfer payments from the provincial and federal governments (primarily federal), employment income to staff of the tribal government, and income from economic development projects, farming and other types of employment. The total of all incomes on the reserve is slightly over $15 million per annum. The education level of the Bloods is below the Alberta average.

The chief and twelve councillors of the tribe have

assumed growing reponsibilities for the self-government of the reserve and now provide a wide range of services through an extensive administration. Although the tribal council has worked hard to increase employment opportunities, a great deal remains to be done. Tribe-owned dryland and irrigated farms are among the projects that have been realized. Agriculture is the prime focus for further economic development.

## B. Study Background

### 1. *Initiation of the Study*

The Blood Tribe has a long history of involvement in irrigation development in southern Alberta, going back to 1922 when the headworks on the Belly River were constructed partially on reserve land for the United Irrigation District. The headworks at this location still supply water to about 34,000 acres of farm land west of the reserve. It was not until 1944, however, 22 years after the headworks had been constructed, that an agreement was signed allowing 20.3 acres of reserve land to be used for that purpose.

In 1947, the Blood Tribe agreed to allow development of the St. Mary Dam and reservoir on 5805.18 acres of reserve land. Again, in 1956 the tribe provided 1676.6 acres of land for the construction of a weir and control gates on the Belly River and for a 43 km diversion canal across the reserve between the Belly River and St. Mary reservoir. These works now supply water to about 400,000 acres of farm land stretching from the reserve to Medicine Hat.

The co-operation of the Blood Tribe and their willingness to provide land for storage and diversion works has not only been a valuable contribution to the development of what has become the largest irrigated area in Canada, but has also resulted in a determination among tribe members to see irrigation farming developed on the reserve.

The agreements signed by the Blood Tribe over the years gave them options from the Province of Alberta for a Water Right License, allowing them sufficient water to irrigate 25,000 acres of reserve land each growing season. The original option obtained prior to the 1956 agreement for the construction of the Belly-St. Mary diversion canal was to have expired on December 31, 1966. In 1961, however, the expiration date for the option was extended to April 1, 1975, and in 1973, it was extended again to April 1, 1984, keeping alive the tribe's hope to develop irrigation farming.

In addition to the Water Right License option, the tribe signed a ten-year agreement with the federal government in 1957, surrendering in trust 37,120 acres of reserve land known as the "Big Lease" to the Government of Canada for lease to others on their behalf. A clause in the agreement authorized the Government of Canada to:

> "... enter into any contractual agreement on our (the tribe's) behalf for the irrigation of all or any part of the described lands, even though the operations of such irrigation plan should continue beyond the terminal date of this release and surrender."

Irrigation on the Big Lease was contemplated more than 25 years ago.

In recent years, preliminary irrigation studies on the reserve have been carried out, and several pilot projects have been developed on individually-held farms in the south central area of the reserve, and on the 1550-acre Mataki project, commonly known as the "potato project", at the north end of the reserve. In total, about 5000 acres of land have been developed for irrigation; of this total, about 2800 acres were irrigated in 1982. Funding has been a major roadblock to development on a larger scale.

In 1977, the minister of Alberta Environment established the Oldman River Study Management Committee to study and make recommendations relative to overall water management in the Oldman River Basin. The Blood Tribe made representation to this committee pointing out social and economic needs and desires for irrigation development. The committee recognized the important role that irrigation could play in improving economic and social conditions on the reserve and felt that the tribe should become involved in on-reserve irrigation development in the near future (Oldman River Basin Study Management Committee; 1978).

In November 1978, the Blood Tribe presented a brief at the Environment Council of Alberta (ECA) public hearings on management of water resources in the Oldman River Basin, again drawing attention to the unfavorable social and economic conditions on the reserve and the potential for agricultural development (Blood Tribal Council; 1978). In its report, the ECA recommended that the Blood Indians form an irrigation district or an equivalent organization that could possibly qualify for funding assistance for irrigation. The ECA recommendation also urged the federal and provincial governments to support irrigation development on the reserve (ECA; 1979).

Following release of the ECA report, a meeting between the Blood Tribe and selected provincial cabinet ministers was held in February 1980, to discuss irrigation development on the reserve. The meeting led to a decision to form a tripartite committee comprised of representatives of the Blood


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## STUDY LOCATION

FIGURE 1

Tribe, and the provincial and federal governments to initiate and manage a study to determine the feasibility of developing irrigation in the northeastern area of the Blood Indian Reserve. The tripartite committee was also to consider issues related to the province and the tribe co-operating in the development of irrigation on the reserve.

The formation of the tripartite committee and its study was the culmination of over 25 years' work by the Blood Tribe to set the stage for large scale irrigation on the thirsty farmland under its control.

## 2. *Management of the Study*

The Blood Indian Irrigation Tripartite Committee performed a management function, directing the activities of the study directorate and an implementation sub-committee. A technical advisory group and various study agencies were established to complete the organizational structure. (Figure 2) The tripartite committee itself was responsible to the participating ministries of the provincial and federal governments and to the Blood Tribal Council.

The tripartite committee consisted of four members representing the provincial government and three members representing the federal government. (The committee members in the organizational structure are listed in Appendix B.)

The tripartite committee appointed an implementation sub-committee to consider the various matters related to implementing the project assuming that irrigation would prove to be feasible. Select members of the tripartite committee and the directorate were appointed to the sub-committee.

The study directorate consisted of a director and co-director appointed by the tripartite committee. The directorate was responsible for implementing activities approved by the committee.

The technical advisory group was composed of resource specialists selected by the directorate primarily from agencies represented on the tripartite committee. The primary responsibility of the group was to provide technical guidance to the directorate and to manage the work of the consultants. The study itself was carried out by the Prairie Farm Rehabilitation Administration (PFRA) and ten consultants. Staff from Alberta Environment, Alberta Agriculture and the Blood Tribal Administration provided input and advice throughout the study.

## 3. *Objectives and Scope*

The overall objective of the study was to determine the feasibility of developing irrigation on the northeastern portion of the Blood Indian Reserve considering technical, economic, social, environmental and administrative factors. All factors that could affect the feasibility and implementation of an irrigation project on the reserve were considered. The study program was broken down into ten components:

1) Mapping
2) Land Classification
3) Agronomy
4) Engineering
5) Groundwater and Salinization
6) Economics
7) Environment
8) Social
9) Implementation
10) Synthesis and Reporting

A statement of the objectives of each study component is given in Appendix C. More detailed terms of reference are provided in the report, *Proposed Feasibility Study of Irrigation on the Blood Indian Reserve* (Hart; 1981).

The study focused on the area known as the Big Lease shown in Figure 3. In terms of its irrigation potential, the Big Lease rates as high as any other area on the reserve considering soils, climate, topography and serviceability, and it has the added advantage of being under the direct administrative control of the tribe. It is currently under cultivation and is being leased primarily to non-Indians.

The Big Lease covers an area of about 34,000 acres, however the target area for irrigation development is 25,000 acres, in keeping with the Blood Tribe's Water Right License option. When the study was initiated, it was not known whether or not there were 25,000 acres of irrigable land within the Big Lease area. The mapping and land classification components of the study were therefore carried out over a larger area, which extended the study boundary south and east of the Big Lease as shown in Figure 3. This extended area could be readily served by water conveyance facilities directed toward the Big Lease. The extension increased the study area to about 61,000 acres. In addition to this, pipeline and canal corridors for water supply and drainage were considered.

It must be recognized at the outset that the investigations carried out in this study were of a level of detail sufficient only to establish the general feasibility of large scale irrigation the reserve. Prior to implementing the project, more detailed studies would be required to firm up design concepts and refine the design of each component of the system to ensure its economic efficiency and optimal performance for the life of the project.

### *Schedule and Funding*

The schedule for the various components is given in Figure 4. The study was initiated in October, 1980 and was to be completed with the finalization of this report originally scheduled for October, 1982.

The study was funded by Alberta Agriculture (mapping component), PFRA (engineering component) and Alberta Environment (all other components). In addition to this, member agencies of the tripartite committee contributed staff time and expenses toward the study.

### *Report Format*

This report provides the study background (Chapter I), a summary of each of the study components (Chapters II to XIII inclusive) and a summary of findings and recommendations (Chapter IX).

Each component study, with exception of the mapping component, culminated in a detailed report. These reports as received from the consultants and PFRA serve as separately bound supplements to this summary report. A list of the supplements is given in the Table of Contents. The conclusions and recommendations of the supplements are the opinions of the respective consultants or PFRA and are not necessarily endorsed by the tripartite committee. The conclusions and recommendations of this summary report may differ in some respects to those of the supplements.

This report uses metric units throughout except for land areas which are expressed in acres. Dual units are given where it is felt that Imperial units are important to convey the meaning of the text or table. Conversion factors for metric and Imperial units are given in Appendix D.

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## STUDY ORGANIZATION

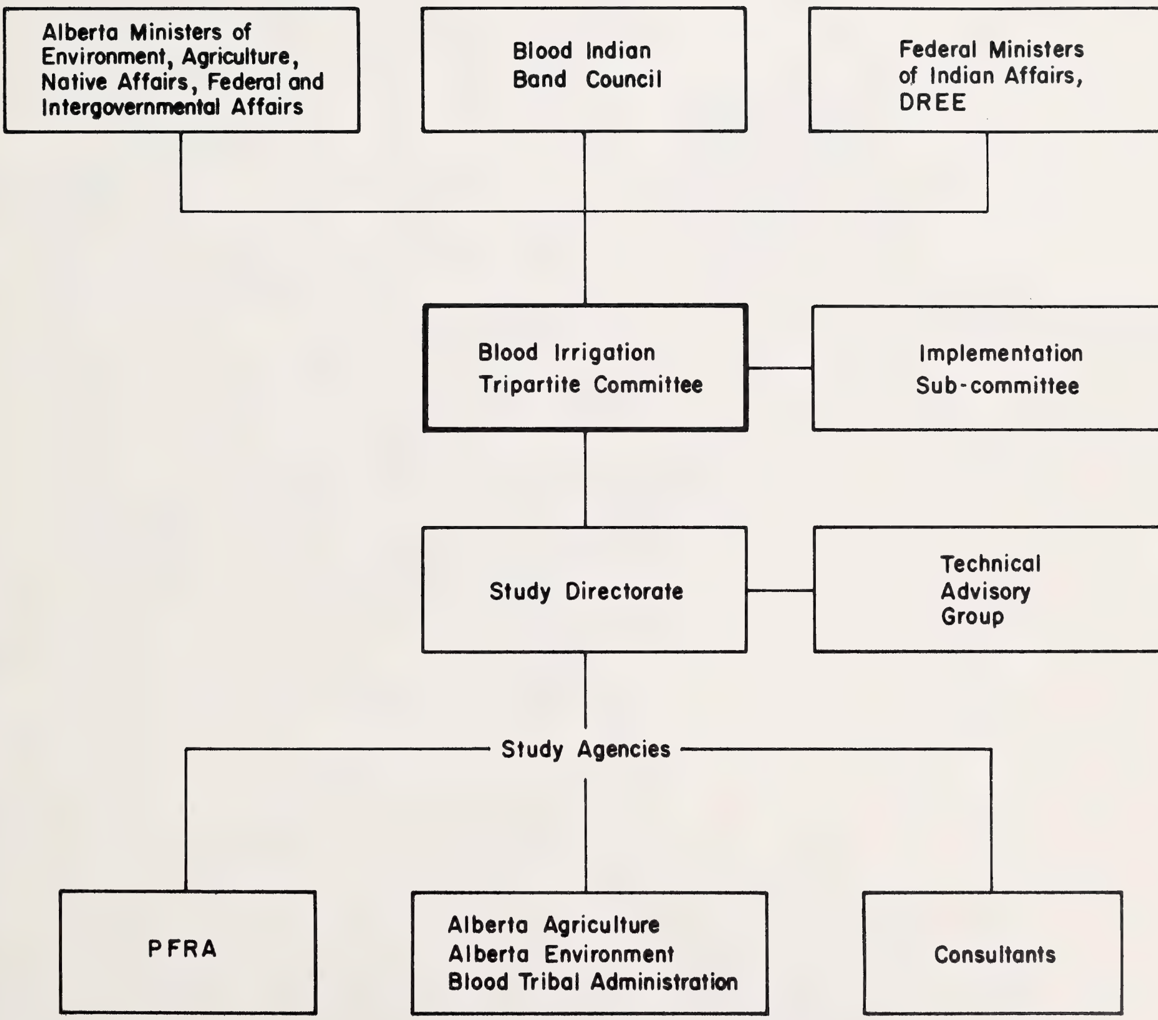
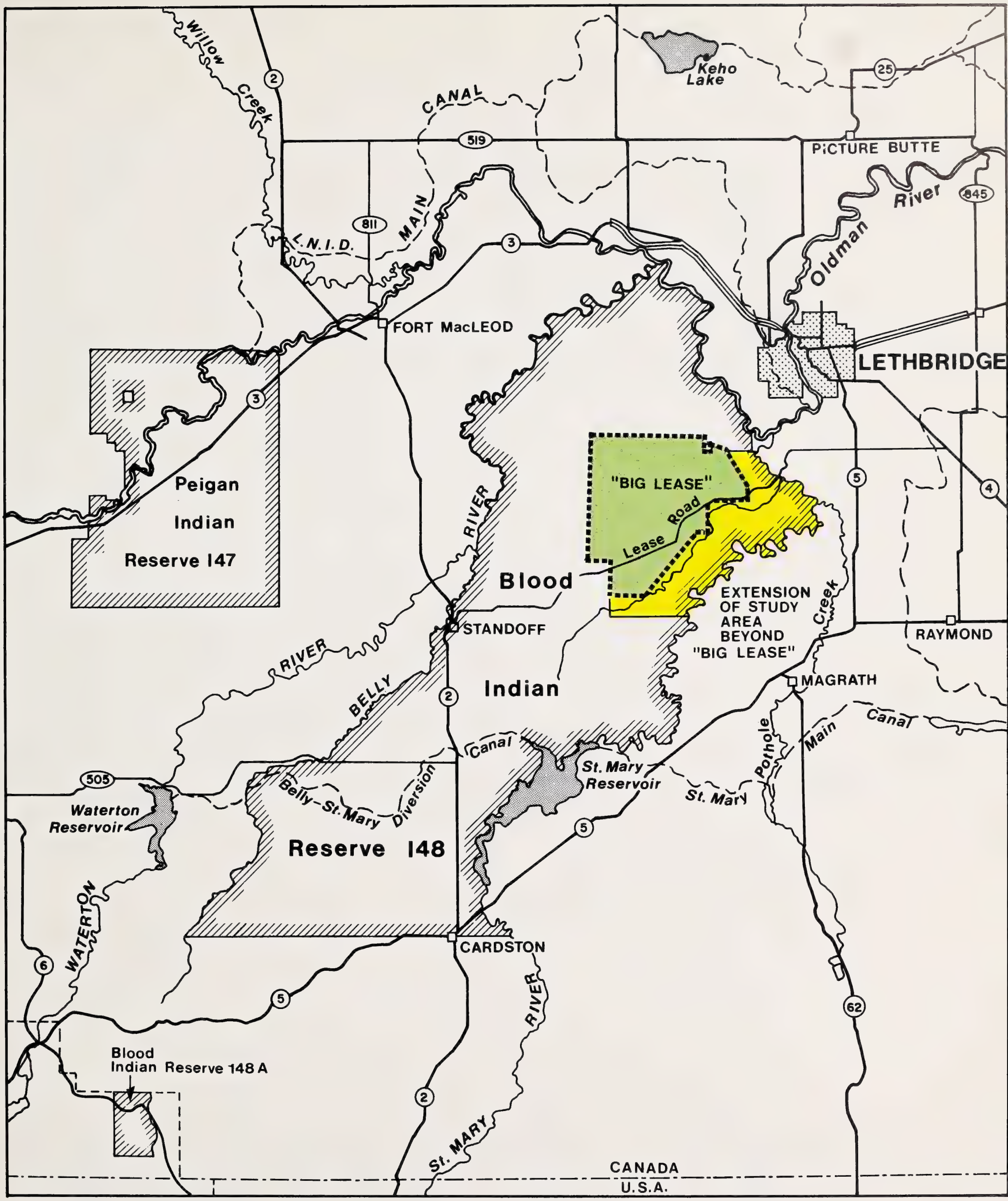



FIGURE 2




IRRIGATION ON THE BLOOD INDIAN RESERVE:
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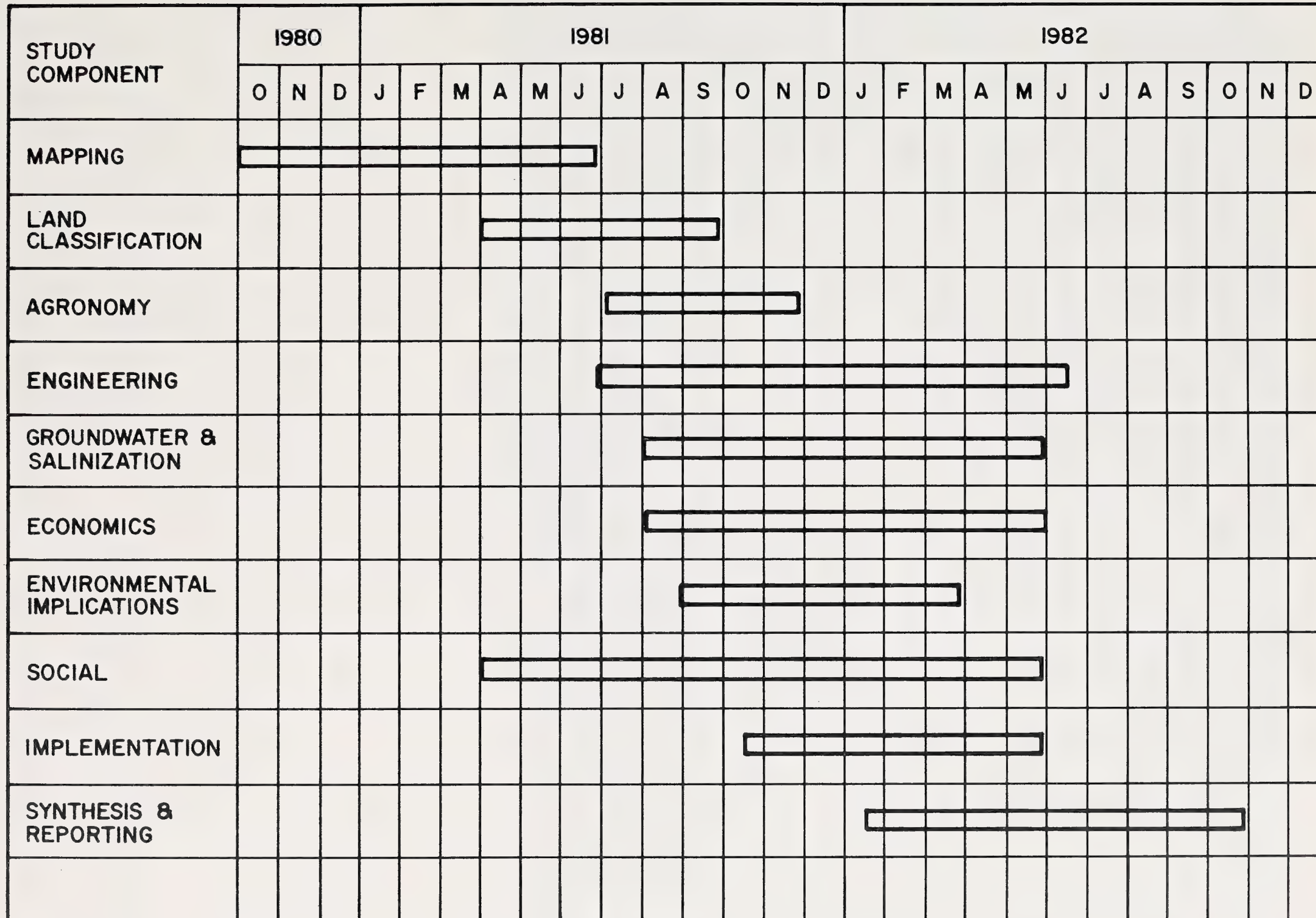
STUDY AREA

FIGURE 3




IRRIGATION ON THE BLOOD INDIAN RESERVE:
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STUDY SCHEDULE

FIGURE 4

# CHAPTER II: MAPPING AND LAND IRRIGABILITY

*Extensive soil sampling was carried out to determine the suitability of the soils in the Big Lease for irrigation.*

## A. Topography

The topography of the Big Lease and the extension area (Figure 3) was mapped to provide information which would allow the land to be classified according to its suitability for irrigation and which would allow for the design and layout of a distribution system to serve the irrigation project.

The mapping was based on 1978 photography scaled at 1:10,000 which was obtained from the federal Department of Energy, Mines and Resources. The mapping program involved ground control surveying, aerial triangulation, and photogrammetric mapping, and was carried out by survey and photogrammetry consultants under the direction of Alberta Agriculture. Topographic maps for about 60,500 acres of land were produced at a scale of 1:2500 with a contour interval of 0.5 metres.

The land in the study area is predominantly gently undulating, sloping from west to east with elevations ranging from 1021 m to 937 m. The surface drainage for most of the study area is eastward and north-eastward to the St. Mary and Oldman Rivers.

In general, the topography is suitable for sprinkler irrigation but is sufficiently undulating to rule out gravity flood irrigation.

## B. The Soil Resource

A total of 444 soil samples taken in the study were analyzed to rate the land according to its suitability for sustained irrigation, to identify potential

soil problems, and to recommend soil management practices for irrigation farming.

Pedology Consultants Ltd., under the direction of Alberta Agriculture, made point observations of soils and extrapolated the information over broad areas using aerial photography, vegetation patterns and principles of geology, pedology and hydrology. On the average, there were four inspection sites to a 2.0 m depth and one to a 4.5 m depth per section of land area. Hydraulic conductivities and infiltration rates were measured at 30 sampling sites. Ratings of soil suitability for irrigation were made in accordance with Alberta Level III standards for irrigation land classification (Water Resources Division; 1969). (A complete description of methodology and findings is given in Supplement 1.)

Land classification maps of the study area at scales of 1:20,000 and 1:40,000 were prepared, showing land units and corresponding land classes; soil, drainage and topographic ratings; soil sub-groups; parent materials and depths; soil textures; and chemical properties of the soil. Physical features such as sloughs, ponding areas, drainage courses and roads were also shown on the maps.

The principal soil subgroups in order of decreasing extent are Orthic Dark Brown, Rego Dark Brown, Calcareous Dark Brown, Gleyed Dark Brown, Orthic Humic Gleysol and Rego Humic Gleysol. Saline phases of these subgroups are common. Important parent materials in decreasing extent include lacustrine deposits of variable depth over till, fluvial-lacustrine deposits of variable depth over till, fluvial deposits and eolian overlaying fluvial and/or lacustrine deposits.

## C. Land Irrigability

The results of the classification of soil types showed that there are about 45,000 acres of irrigable land in the Big Lease and extension areas. About 16,000 acres are non-irrigable; however with the omission of small parcels of irrigable land within non-irrigable blocks, plus areas occupied by roads, farmsteads and, in the future, irrigation canals and drainage ditches, the total irrigable acreage will be reduced somewhat.

Figure 5 shows five general areas representing various levels of suitability for irrigation development. It integrates all available information on the suitability of the land for irrigation farming. Area A is most suitable for irrigation and should be given priority; Area B is somewhat less suitable; and so forth. Area E is non-irrigable. The total area of each level of suitability within the Big Lease and extension areas is summarized in Table 1.

Area A has the best agricultural soil for both dryland and irrigation farming. The area is gently undulating with an easterly slope. Top soil textures range from loams to clay loams, and subsurface materials include clay loams, silty clay loams and silty clays. Salinity and sodicity levels are low and moisture holding capacity is high. The soils have slow infiltration rates which would require low sprinker application rates. Low-lying areas are few but are subject to frequent ponding and water tables lay within 2.0 m of the surface for a significant portion of the growing season. If Area A is irrigated, surface and possibly subsurface drainage will be required to prevent a rise in the water table and increased salinity in the root zone. The low hydraulic conductivities in Area A may be an impediment to successful subsurface drainage.

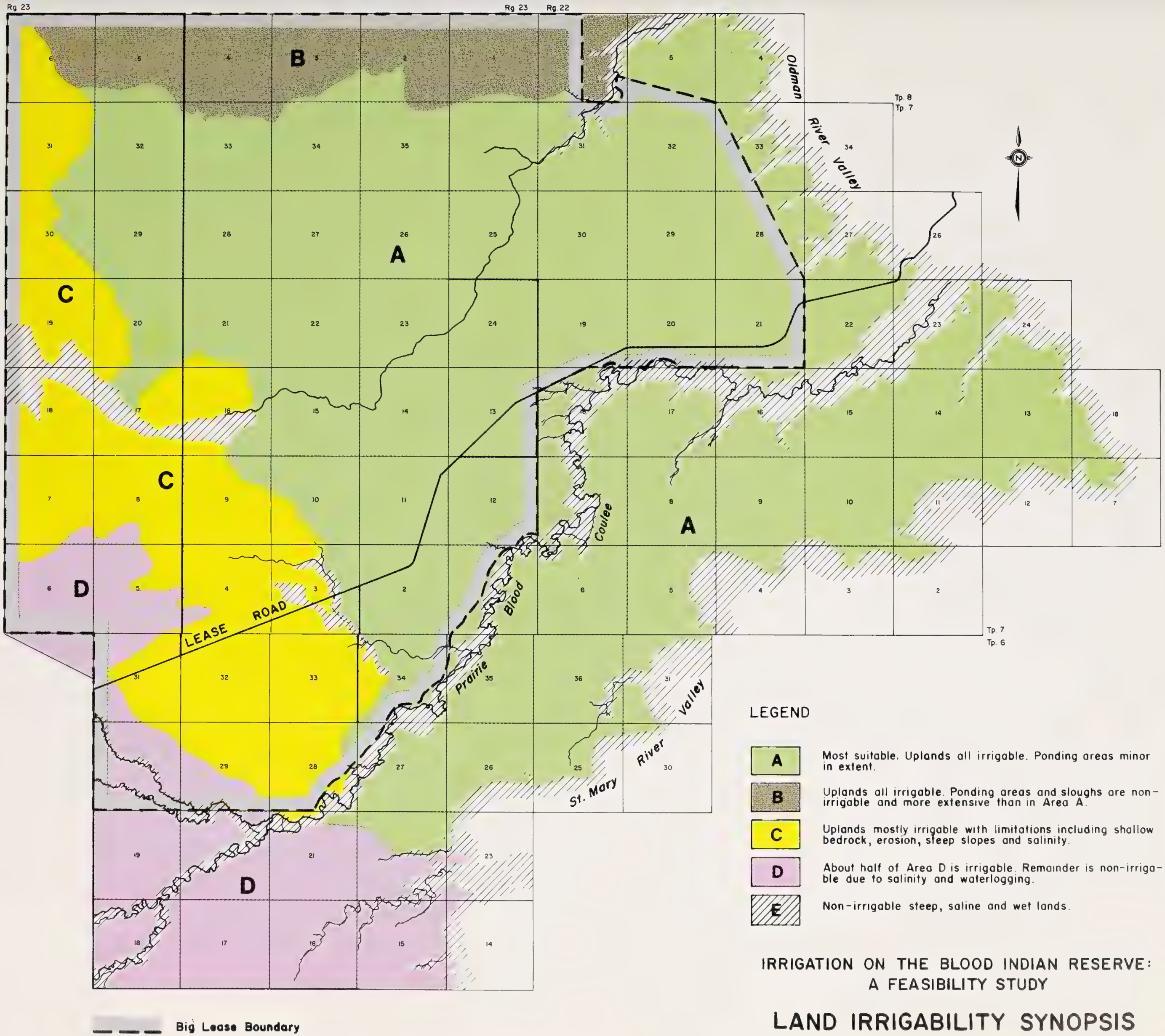
Area B contains soils that are suitable for irrigation farming but are moderately stony, requiring some clearing. There are some sandy patches, which have a low moisture-holding capacity and have some problems with soil drifting. The topography in B areas is gently undulating and salinity and sodicity levels are low. Small sloughs and ponding areas are scattered throughout Area B, and local waterlogging and salinity problems may arise due to lateral seepage. Drainage for most of the sloughs and ponding areas should be provided as part of the irrigation development.

Area C contains shallow bed rock and poorly-drained soils in places, and significant levels of saline, eroded and poorly-drained soils which are non-irrigable. Irrigation of good upland soils in Area C would likely cause additional waterlogging and salinity problems in low-lying areas. Subsurface drainage would be required, but slow hydraulic conductivities make such drainage difficult and the discharge of salts may have detrimental environmental effects. Area C is considered inferior for irrigation development.

Area D contains approximately equal amounts of irrigable and non-irrigable soils. The non-irrigable soils are saline and poorly drained, and irrigating the upland soils would increase salinity and waterlogging problems in low-lying areas. Irrigation should not be considered in Area D.

Area E includes coulees and river valleys. The slopes are steep, and valley bottoms, where flat, are saline and waterlogged, and parts are subject to flooding. Area E is unsuitable for irrigation.

The highest priority for irrigation development should be given to Areas A and B. From Table 1, there are a total of 25,500 acres of Area A and B land within the Big Lease — slightly more than the target irrigation acreage of 25,000 acres. The

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## LAND IRRIGABILITY SYNOPSIS

FIGURE 5

*Table 1*

SUMMARY OF IRRIGATION SUITABILITY LEVELS

| Suitability Level | Big Lease (acres) | Extension (acres) | Comments |
|---|---|---|---|
| A | 22,000 | 10,000 | most suitable for irrigation |
| B | 3,500 | 1,500 | scattered sloughs and ponding |
| C | 9,500 | 0 | includes saline, eroded and poorly drained soils |
| D | 2,500 | 4,500 | 50% is non-irrigable |
| E | 1,500 | 6,000 | unsuitable for irrigation |

25,500-acre figure includes areas occupied by roads, ditches, farmsites and other non-irrigable land. After carefully considering the results of the land classification study, the servicing problems, and land tenure in the Big Lease and extension areas, the tripartite committee concluded that the remainder of the feasibility study should focus on developing Areas A and B within the Big Lease. However, the committee recommended that the water conveyance facilities required to service the Big Lease be designed to have the capacity and capability to release water to Prairie Blood Coulee for stockwatering and private irrigation development in the extension area south of Prairie Blood Coulee.

## D. Soil Management Practices

The soils in the majority of the study area are finely textured and have slow infiltration rates and slow hydraulic conductivities. Due to these factors and the undulating topography, sprinkler irrigation with low application rates is recommended for the study area.

Generally speaking, the soil has a high moisture holding capacity, and careful scheduling and control of water application would be necessary to minimize any increase in the level of the water table, and hence, the need for subsurface drainage.

Ponding areas and sloughs should be surface drained where practical in the early stages of development to increase productivity and accessibility and to minimize the rise in the water table. Saline seepage areas and the adjacent upland should not be irrigated. As subsurface drainage would be difficult and costly, it would be important to take corrective measures at the first indications of any waterlogging or water table problems. The water table should be monitored at various locations throughout the study area.

# CHAPTER III: AGRONOMY

*Irrigation would increase the yields realized from crops currently grown on dryland farms, and would permit specialty crops to be grown.*

An agronomy study was carried out to determine what crop types could be grown in the study area, and what their respective yields and water requirements might be, considering climatic conditions, topography and soil characteristics. The study was conducted by Marv Anderson and Associates Limited under direction of Alberta Agriculture. (Supplement 2 provides a detailed description of the findings of the study.)

## A. Climate of the Study Area

The Big Lease has a continental prairie climate characterized by cold winters, warm summers and relatively low precipitation.

Table 2 shows the mean monthly temperatures in the region. In the summer, the average daily temperature is about 15°C, although daytime temperatures frequently exceed 27°C and occasionally exceed 38°C, while at night, temperatures are usually comfortably cool. The frost-free period is about 115 days, although the variation is extreme. In one year out of 10, the last frost can be expected in mid-June or the first frost in late August. Periodically, spring and fall frost damage to crops can be expected. The average monthly temperature is below the freezing point for the five-month period from November through March.

The available heat units, which are an indication of the ability to produce crops, are sufficient to permit rapid growth of most crops if other requirements are satisfied. In the study area, the number of growing degree-days above 5°C averages about 1700. The corn heat units[1] average about 2200 per annum.

The average monthly and annual precipitation data for the region is given in Table 3. The average annual precipitation in the Big Lease is about 450 mm, however it is extremely variable from year to year: for instance, at Lethbridge where the annual average is 436 mm, it has varied from a high of 709 mm to a low of 194 mm. About 60 percent of the total annual precipitation (270 mm) occurs as rainfall during the growing season; about 40 percent (180 mm) occurs during May, June and July when it is most needed for plant growth.

The prevailing winds in the Big Lease are from the west and southwest, averaging about 25 km/h, however speeds of 120 km/h are not uncommon and 160 km/h is exceeded occasionally. These higher winds are typical of southern Alberta, and can result in soil drifting. They may adversely affect sprinkler irrigation as well.

The region is characterized by warm southwesterly Chinook winds throughout much of the year, winds which may remove snow cover in the winter and

[1] Corn heat units are computed on the basis of temperatures above 10°C and below 30°C in the daytime, and above 5°C at night.

increase evapotranspiration losses in the summer, possibly resulting in winter-kill and crop stress.

Hail occurs less frequently on the reserve than it does in many other agricultural areas of Alberta. On a long-term average, hail might be expected to occur once every 25 years.

## B. Crop Types/Yields

Most lands on the Big Lease are managed by the Blood Band and leased annually to non-Indians. The current farming practice on the Big Lease is to seed large crop blocks using big equipment and very little labor. Wet and/or alkaline areas are not cultivated. The proportion of land seeded to cereals, oilseeds and summerfallow crops in 1981 was approximately as follows:

| | |
|---|---|
| Cereals | 65.9% |
| Oilseeds | 10.7% |
| Summerfallow | 23.4% |

In general, dryland yields in the Big Lease are somewhat lower than yields in others parts of the reserve and surrounding areas. The estimated dryland yields on the Big Lease in 1981, a relatively good year, were:

| | |
|---|---|
| Spring Wheat | 2.0 tonne/ha (30 bus/ac) |
| Winter Wheat | 2.7 tonne/ha (40 bu/ac) |
| Barley | 2.4 tonne/ha (4 bu/ac) |
| Canola | 1.2 tonne/ha (20 bu/ac) |

The average dryland yields are expected to be slightly lower than 1981 yields.

The crop types which would be produced under irrigation in the Big Lease are dependent upon climatic limitations, production risks, marketing opportunities, and managerial preferences and capabilities. Hot, dry Chinook winds may increase crop stress, and spring and fall frost damage can be expected periodically. Low risk crops include alfalfa, barley, spring wheat, winter wheat and canola, while more specialized crops which are subject to greater production and marketing uncertainties are potatoes, silage corn, beans, lentils and peas.

From a review of the production patterns within the irrigation districts adjacent to the reserve and on private and tribal irrigation projects on the reserve, as well as from a review of the historic and potential agricultural pursuits on the reserve, a representative irrigation crop mix would be:

| | |
|---|---|
| Alfalfa | 40% |
| Cereals | 40% |
| Oilseeds | 15% |
| Specialty Crops | 5% |

The types of crops grown on the reserve will likely vary as market conditions and managerial skills change. The above crop mix is typical of the general area and provides a realistic estimate of the project's water requirements and its relative benefits and costs.

Crop yields under irrigation farming are dependent upon the technological and management capabilities of the farm operators. Three yield levels and their respective constraints are shown on Figure 6.

Level 1 yields, or existing irrigation farm yields, were estimated on the basis of average yields for various crop types on irrigation farms in the surrounding area. These yields were considered to be the minimum yield expectation for the Big Lease. The other extreme, Level III yields, represent those of experimental stations, and represent the upper limit of attainable yields under the prevailing physical conditions and optimal technological and management applications. The Level II yields, the potential farm yields, are the most difficult to estimate since there are many intangible constraints that must be considered (Figure 6). Professional judgement estimates that the Level II yields would fall midway (or slightly lower) between Level I and Level III yields. At the same time, they represent above-average on-farm management skills being applied.

Levels I, II and III yields for typical crop types are given in Table 4. It is very difficult to anticipate the management and technological level that would apply to irrigation farming in the Big Lease; accordingly, the economic evaluation of irrigating on the Big Lease must consider a range of possible yields. The Level II estimates should serve as the base case, and a sensitivity analysis should consider yields of plus and minus 20 percent from the base case which would approximate Level I and Level III yields.

## C. Crop Water Requirements

The irrigation water requirement for the Big Lease is dependent upon the crops grown, the quantity and timing of precipitation and the yield objectives. For maximum yields (Level III) the estimated monthly water surpluses or deficits for various crop types and for a representative crop mix in the Big Lease are given in Table 5. The average annual irrigation requirement would be about 210 mm. The peak monthly requirement would occur in July and would be about 155 mm in an average year. In dry years more water would be required for maximum yields than shown in Table 5; on the other hand

*Table 2*

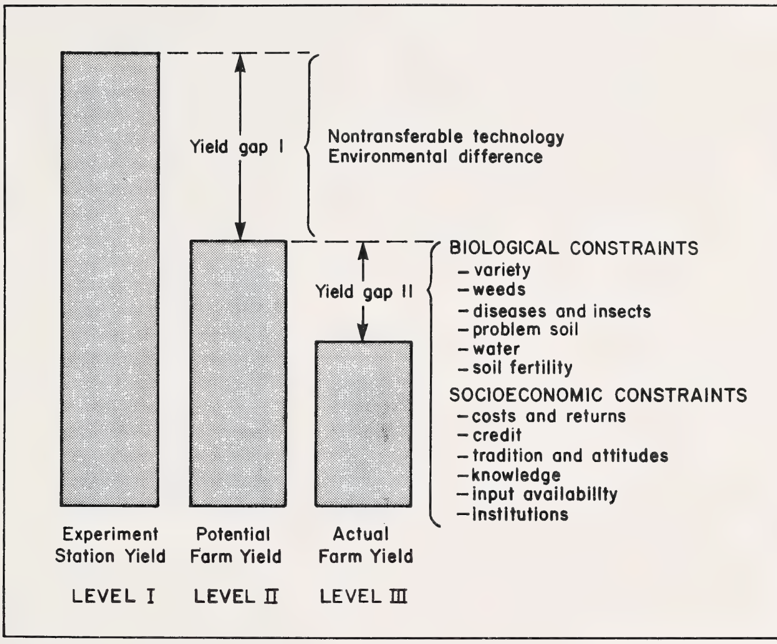
REGIONAL TEMPERATURE DATA (1941 - 1970)

| Station | Mean Monthly Temperatures °C | | | | | | | | | | | | Frost Free Period (Days) | Degree Days >50°C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D | | |
| Cardston | -7.8 | -4.9 | -3.0 | 4.3 | 9.8 | 13.4 | 17.3 | 16.0 | 11.0 | 6.7 | -0.7 | -4.9 | 108 | 1,520.7 |
| Ft. MacLeod | -8.9 | -4.9 | -2.2 | 5.4 | 10.9 | 14.9 | 18.8 | 17.5 | 12.5 | 8.0 | -0.2 | -4.8 | 124 | 1,784.8 |
| Lethbridge (A) | -9.4 | -5.6 | -2.4 | 5.3 | 10.9 | 14.9 | 18.8 | 17.6 | 12.7 | 7.6 | -0.7 | -5.5 | 118 | 1,775.8 |
| Magrath | -8.8 | -4.7 | -2.0 | 5.1 | 10.7 | 14.5 | 18.5 | 17.4 | 12.4 | 7.8 | -0.7 | -5.1 | 115 | 1,669.0 |

*Table 3*

REGIONAL PRECIPITATION DATA (1941 - 1970)

| Station | Mean Monthly Precipitation (mm) | | | | | | | | | | | | May — September Mean (mm) | Annual Mean (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | F | M | A | M | J | J | A | S | O | N | D | | |
| Cardston | 23.6 | 26.7 | 29.0 | 40.9 | 65.3 | 103.4 | 43.4 | 40.6 | 46.7 | 23.6 | 25.9 | 25.4 | 299.4 | 494.5 |
| Ft. MacLeod | 20.3 | 23.4 | 25.1 | 32.3 | 59.7 | 97.8 | 40.4 | 41.9 | 40.1 | 18.5 | 19.8 | 20.8 | 279.9 | 440.1 |
| Lethbridge (A) | 22.9 | 22.4 | 25.7 | 35.8 | 51.1 | 89.4 | 45.0 | 39.4 | 37.3 | 22.9 | 23.1 | 21.3 | 262.2 | 463.3 |
| Magrath | | | | 37.8 | 57.7 | 96.0 | 53.1 | 42.7 | | | | | 289.6 | |
| Standoff | 21.6 | 26.2 | 26.4 | 41.1 | 61.2 | 105.9 | 40.1 | 39.4 | 47.8 | 21.6 | 18.5 | 19.3 | 294.4 | 469.1 |




CROP YIELDS AND CONSTRAINTS

Adapted from: GOMEZ; 1978

FIGURE 6

*Table 4*

TYPICAL IRRIGATION CROP YIELDS

| Crop Type | Units | Level I (minimum) | Level II (base case) | Level III (maximum) |
|---|---|---|---|---|
| spring wheat | tonne/ha | 3.4 | 4.0 | 6.2 |
| | bu/ac | 51 | 60 | 91 |
| barley | tonne/ha | 4.0 | 5.4 | 6.9 |
| | bu/ac | 73 | 100 | 128 |
| alfalfa | tonne/ha | 9.0 | 9.3 | 14.1 |
| | ton/ac | 4.0 | 4.2 | 6.3 |
| sugar beets | tonne/ha | 38.1 | 46.3 | 58.1 |
| | ton/ac | 17.0 | 20.7 | 25.9 |
| canola | tonne/ha | 2.2 | 2.9 | 3.6 |
| | bu/ac | 37 | 49.6 | 62 |
| sweet corn | tonne/ha | 12.1 | 16.2 | 20.4 |
| | ton/ac | 5.4 | 7.25 | 9.1 |
| green peas | tonne/ha | 2.0 | 2.8 | 3.6 |
| | ton/ac | 0.90 | 1.25 | 1.6 |
| dry beans | tonne/ha | 1.4 | 1.9 | 2.4 |
| | bu/ac | 21 | 28 | 35 |

*Table 5*

AVERAGE WATER DEFICIT FOR THE BIG LEASE (mm)

(For data sources, see Supplement 2, page 59)

| Month | Crop | | | | Composite Water Use[a] | Available Average Precipitation | NET SURPLUS OR DEFICIT | |
|---|---|---|---|---|---|---|---|---|
| | Alfalfa (1) | Cereals (2) | Oilseeds (3) | Specialty (4) | | | Monthly | Cumulative |
| Soil Moisture Reserve | | | | | | 63.5 | | 63.5 |
| May | 100 | 35 | 20 | 30 | 59 | 51.6 | -7.4 | 56.1 |
| June | 155 | 145 | 135 | 110 | 146 | 87.9 | -58.1 | -2.0 |
| July | 170 | 210 | 210 | 165 | 193 | 37.6 | -155.4 | -157.4 |
| Aug. | 95 | 90 | 40 | 160 | 88 | 36.2 | -51.8 | -209.2 |
| Sept. | 90 | — | — | 45 | 38 | 37.5 | -0.5 | -209.7 |
| TOTAL | 610 | 480 | 405 | 510 | 524 | 314.3 | | |

[a] Weighed according to a representative crop mix: alfalfa 40%, cereals 40%, oilseeds 15%, and specialty crops 5%

Level II yields (more typical base case yields) could probably be attained with less water than shown in Table 5.

Peak July requirements are generally used to determine the size of the irrigation facilities required for each farm unit. The daily July water requirements for varying degrees of natural moisture and for the representative crop mix in the Big Lease are as follows:

| | |
|---|---|
| 1:10 Dry Year | 5.4 mm |
| 1:4 Dry Year | 5.1 mm |
| Median Year | 5.0 mm |
| 1:4 Wet Year | 4.3 mm |
| 1:10 Wet Year | 2.2 mm |

Because of frequent high winds in southern Alberta, losses of up to 30 percent would be possible for sprinker irrigation systems. Gross July water requirements would range from 7.1 to 7.7 mm per day for median and 1:10 dry years respectively. Most center pivot irrigation systems currently in use are designed to deliver 6.8 to 7.4 mm of gross moisture per day (800 U.S. gallons per minute). Considering Level II yields, this rate of delivery would probably be just sufficient to service the water deficit in median and dry years. Using this rate of delivery, each quarter section pivot (132 irrigated acres) would require about 0.050 $m^3/s$. A total development of 25,000 acres could potentially have a water requirement of 9.4 $m^3/s$. Recognizing that not all sprinklers will be operating at the same time even during peak demand periods, the design flow for the distribution systems was reduced by 15 percent to 7.9 $m^3/s$. Upon more detailed study it may be possible to further reduce this design flow, particularly if towable quarter section pivots or full section pivots proved to be feasible.

## D. Irrigation Technology

Because of the slow infiltration rates of the soil types found in the Big Lease and because of undulating topography, sprinker irrigation systems are recommended. There is a variety of sprinkler systems from which to choose, including wheel roll, center pivot, hand move, high volume guns, and linear move. Wheel rolls and center pivots are most commonly used in southern Alberta, center pivots becoming increasingly popular due to low labor requirements.

The wheel roll system (Figure 7) consists of a lateral water supply pipeline, which also serves as an axle for the wheels, and a mover unit. The mover is located in the middle of the lateral and generally uses a gasoline engine and an oil hydraulic pump to transmit a torque to the pipe. After irrigation is completed as a set, the system is drained and disconnected from the mainline. The power mover is then used to roll the lateral to the next set on the mainline. Semi self-propelled units are available.

A typical wheel roll system in southern Alberta would have two 400 m (¼ mile) laterals on a quarter section with a mainline running down the middle of the field. Each lateral would have 32 sprinklers and would irrigate 1.82 acres in a single set. Sets would be spaced at 18 m. The length of the lateral, the diameter of the pipe, and wheel size and spacing can vary. Special movers are available that will move 800 m of pipe. Certain high-value crops and those dependent on precise moisture conditions could require four laterals on a quarter section.

A center pivot system (Figure 8) consists of a lateral mounted on high towers and attached to a pivot point at the center of the field. The lateral rotates around the pivot while irrigating and, hence, very little labor is required. Towable center pivots are available that can be used on two circles if crop type, climatic conditions and soils are such that water requirements can be met on two circles.

A "standard" center pivot irrigates only 132 acres out of a quarter section. About 28 acres remain dry in the four corners. End guns or corner booms on trailing towers that swing out in the corners and retract when the lateral is perpendicular to field boundaries have become very popular, as they increase the area that is irrigated to 150 to 155 acres in a quarter section.

Crop types, topography, weather conditions, labor availability and soil characteristics must be considered in selecting the appropriate type of sprinkler system for a specific application. For unimpeded quarter section blocks on the Big Lease, center pivot systems with end guns were assumed for the purposes of this feasibility study. For irregularly-shaped fields, wheel roll systems would be required. In the final design stage of this project, more detailed studies of the soils, agronomy and system designs would be required to determine the appropriate equipment, application rate, nozzle type and pressure requirements. Field experimentation in the early stages of development may also be required. For some crop types, full section pivots may be feasible which could reduce on-farm costs.

Regardless of the selected method of irrigation, the key to the success of the project is proper management. Maintaining good soil conditions in the irrigated area, using effective crop rotations, and providing timely irrigation are essential to minimizing on-farm costs and optimizing yields. For example, with good management, it may be possible to maintain a high soil moisture level in June which could effectively reduce peak water requirements in July. For certain crop types, this may allow a farmer

to use a single pivot on two circles of different crop types without causing significant plant stress.

## E. Development Plan

Given the relative inexperience of band members in irrigation farming and the tenure of the Big Lease land, it is assumed that, at least initially, irrigation development on the Big Lease would be controlled by a central organization rather than by individual farmers. Land development should be phased in over a sufficiently long period, say ten years, at an average rate of 2500 acres per year, to provide for the gradual development of on-reserve agronomic expertise, the development of markets, and the phasing out of dryland leases and revenues therefrom. Each new irrigation block, or a portion thereof, could be treated as a semi-independent management unit in terms of crop types, rotations, equipment, labor requirements, etc.

Based on agronomic, engineering, and management considerations, a ten-year development plan has been proposed as shown on Figure 9. During the first six years, irrigation would develop from west to east on the northern half of the Big Lease using center pivot systems. In year seven, development would begin in the southern half. In year ten, wheel-move systems would be used for infilling along roads and in irregular areas. To irrigate the full 25,000 acres, corner systems would be required on the center pivots, and some irrigation on privately-claimed land outside the Big Lease would be required. Corner systems could be incorporated with initial installation of the center pivot or retrofitted at any time during the development phase. If the land is suitable, private irrigation development along the conveyance route between the Belly-St. Mary Canal and the Big Lease would probably occur. The other areas most promising for the extension of irrigation outside the Big Lease are the areas south and east along Prairie Blood Coulee and along the northern boundary of the Big Lease.

This development scenario does not include development of lands in the west and southwest of the Big Lease with a Class C, D or E irrigability rating. It is assumed that the surface drainage work for each block would precede the development of that block.

Two alternative distribution systems for conveying water to the land are presented in the engineering chapter of this report.

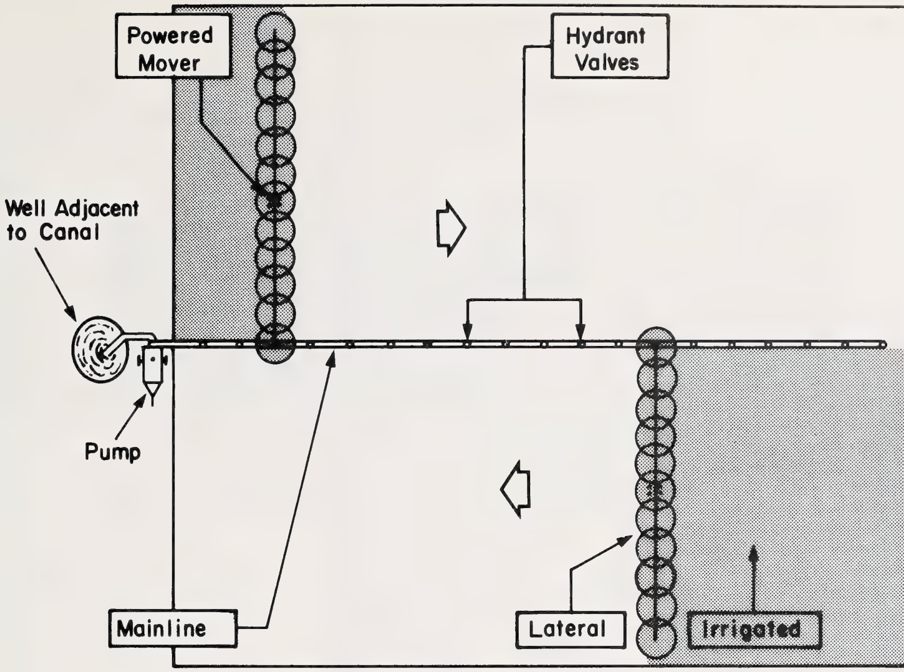



Figure 7 - WHEEL-ROLL IRRIGATION

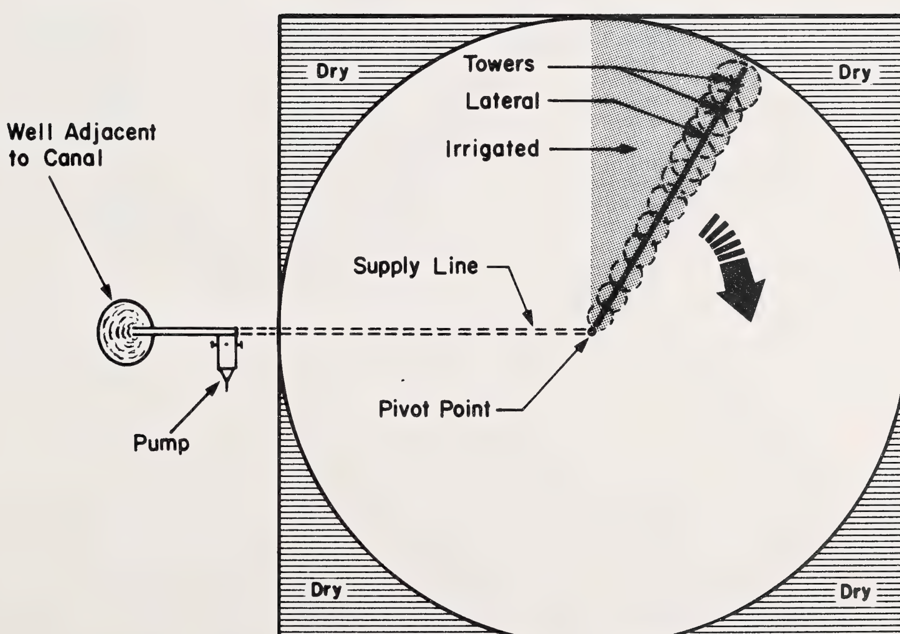
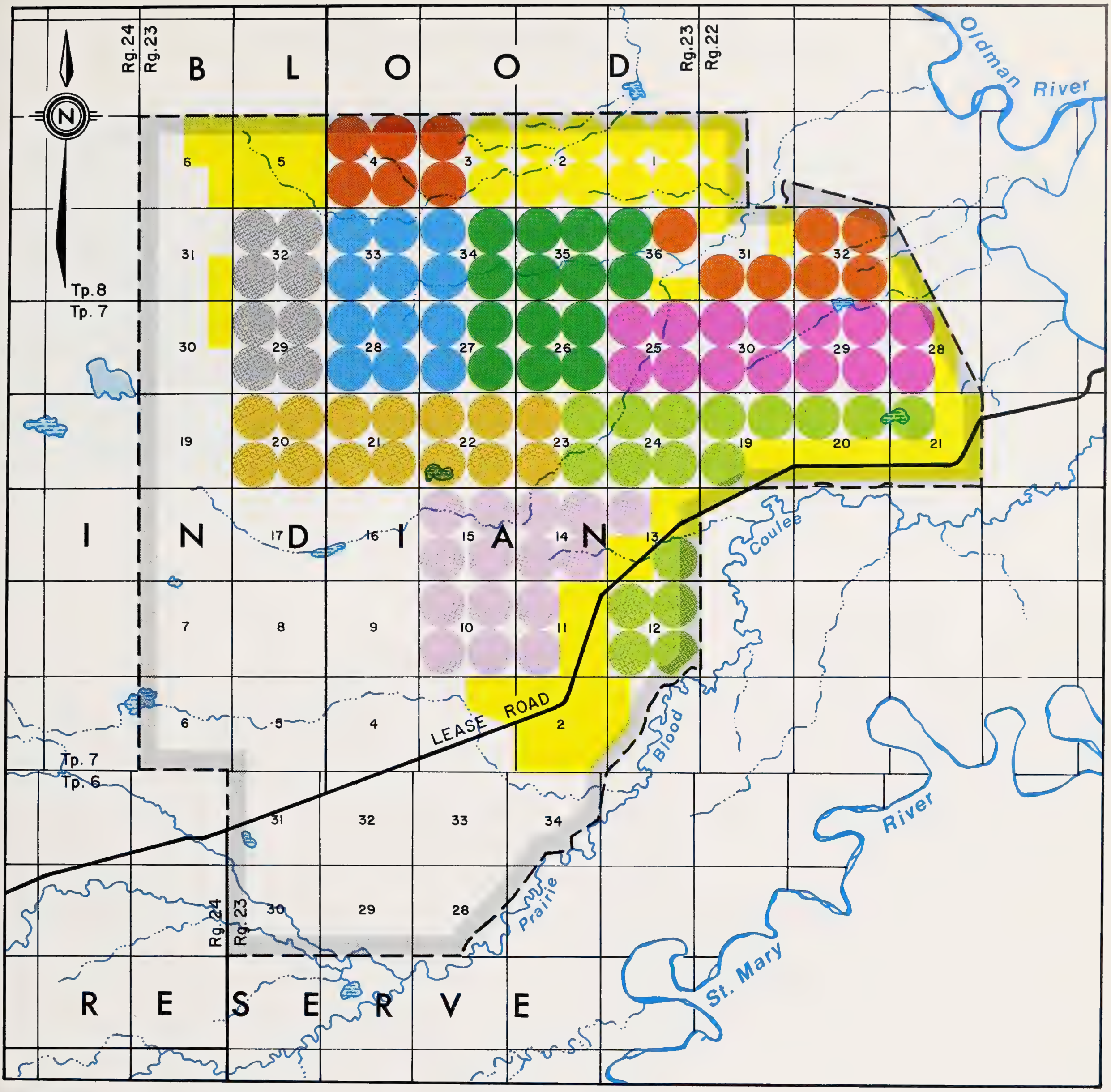



Figure 8 - CENTER PIVOT IRRIGATION




Big Lease Boundary

DEVELOPMENT SCHEDULE

Year One – Centre Pivot

Year Two – Centre Pivot

Year Three – Centre Pivot

Year Four – Centre Pivot

Year Five – Centre Pivot

Year Six – Centre Pivot

Year Seven – Centre Pivot

Year Eight – Centre Pivot

Year Nine – Centre Pivot

Year Ten – Side Roll

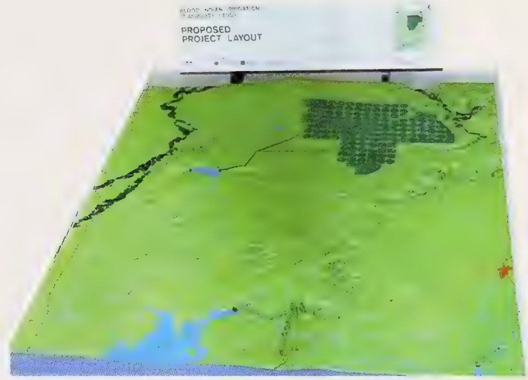


## BIG LEASE IRRIGATION DEVELOPMENT PLAN

FIGURE 9

# CHAPTER IV: ENGINEERING

*Modern irrigation equipment leaves a green and growing crop in its wake.*




*A physical model showing the layout of the project will be used by the tribe in making presentations to government and business leaders.*

The engineering studies evaluated alternative water supply sources and provided preliminary designs and cost estimates for conveyance facilities to bring water to the Big Lease, a distribution system to service the irrigable land, and a drainage system to return excess water to the St. Mary River. The engineering designs were of sufficient detail to provide cost estimates within ±25 percent. The engineering study was conducted by PFRA and is reported in detail in Supplement 3. The work involved carrying out field surveys, mapping, hydrological investigations, and developing design and cost estimates.

## A. Water Supply

The water supply for the proposed project would be an integral part of the existing river-reservoir-canal system which supplies water to several irrigation districts in southern Alberta. Three alternative water supply sources and several conveyance routes were considered in the engineering study, as shown in Figure 10. All alternatives include a balancing reservoir near the irrigable land which would simplify the operation and management of the project and provide carry-over storage for emergency canal repairs and short-duration peak water demands.

In Alternative Source 1, water would be diverted from the Belly-St. Mary Diversion Canal by means of a combination check-turnout structure on the canal. The diverted water could be conveyed via the Mokowan Ridge Canal (Route 1) almost due north to Mokowan Reservoir, or Reservoir A, from which it would be distributed to the irrigable land. Alternatively, water could be conveyed via a gravity canal northward and eastward to Prairie Blood Coulee (Route 2) and Reservoir B. It could then be distributed to the irrigable land from Reservoir B. Because of steep slopes along Route 2, several major drop structures and channel improvements along Prairie Blood Coulee would be required to control erosion.

Alternative Source 2 would involve pumping water from the St. Mary Reservoir and conveying it via a 1500 m long closed conduit and a 4000 m long gravity canal to Prairie Blood Coulee, and along Prairie Blood Coulee to Reservoir B. Alternatively, the water pumped from the St. Mary Reservoir could be conveyed via a closed conduit and a gravity canal to the Mokowan Ridge Canal (Route 4), where it would be conveyed to Mokowan Reservoir or Reservoir A. The pump lift required for these alternatives would be up to 47 m depending on the level of the St. Mary Reservoir.

In Alternative Source 3, water would be pumped from the St. Mary River and would be conveyed by closed conduit for about 180 m, and then by gravity canal for about 8000 m to Reservoir B on Prairie Blood Coulee (Route 5). A weir on the St. Mary River would be required to create a pumping pond. The pump lift in this case would be about 63 m.

Although the irrigable area in the proposed project is small in relation to the total land served by the Waterton-Belly-St. Mary system (about 5 percent), supplying water to the proposed project will un-

doubtedly have some effect on the operation of the existing system and on future expansion of irrigation outside the reserve. Determining the nature and the magnitude of the effect would involve a very complicated analysis that would have to consider water use priorities, operating rules, and future development scenarios. Such an analysis is beyond the scope of this feasibility study, however, the proposed project is being considered along with numerous other water use and management options in a much larger study of water management in the South Saskatchewan River Basin. Recognizing that a water right for irrigating 25,000 acres on the Blood Indian Reserve is a long-standing commitment of the provincial government to the Blood Band, this study assessed the capability of the existing river-reservoir-canal system to supply water to the proposed project within the context of the present upstream demands and modes of operation.

A preliminary hydrology study was conducted to determine whether or not each of the three alternative sources could reliably satisfy demands of the Blood Indian irrigation project using flows remaining (residual flows) in the Waterton, Belly and St. Mary rivers assuming the following demands are met:

1) A United States demand of one-half the natural flow at the International Boundary (an approximation of the full United States entitlement).
2) The full irrigation requirement of the Aetna, Leavitt, Mountain View and United Irrigation Districts.
3) The minimum downstream flow below the Waterton Dam, Belly River diversion weir and the St. Mary Dam of 0.85 $m^3/s$ at each location.

The study concluded that there is sufficient residual flow in the Belly and Waterton rivers to irrigate the proposed project from Source 1, however, it may be necessary to provide a check structure in the Belly-St. Mary Diversion Canal to maintain an adequate head for diversion. Similarly, there is sufficient combined residual flow in the Waterton, Belly and St. Mary rivers to meet the needs of the proposed project from Sources 2 or 3. In other words, from a hydrological perspective, all three alternative sources of water have the capability of meeting the irrigation demand on the reserve.

Comparative capital and annual cost estimates were prepared for works required to convey water to the reservoirs near the proposed irrigation project from each alternative source of supply and for each conveyance route. The results indicated a decided cost advantage in favor of a total gravity diversion and conveyance system rather than a combined pump and gravity scheme. The capital costs for pump diversions from Sources 2 and 3 would be two-and-one-half to three times greater than the gravity diversion from Source 1. Annual costs indicated similar ratios. Sources 2 and 3 were therefore eliminated from any further consideration.

Water could be conveyed to the Big Lease from the Belly-St. Mary Diversion Canal by either the Mokowan Ridge Canal or Prairie Blood Coulee shown as Routes 1 and 2 respectively on Figure 10. The preliminary cost estimates for each route were comparable. The Mokowan Ridge Canal would be at a higher elevation than the Prairie Blood Coulee route. Mokowan Reservoir could be at an elevation high enough to permit water to be delivered to the Big Lease via closed conduit under pressure, eliminating most of the pumping costs for sprinkler irrigation. The main advantages of the Prairie Blood Coulee route are that there would be less cultivated land taken out of production and fewer severance problems since water would be conveyed via a natural channel.

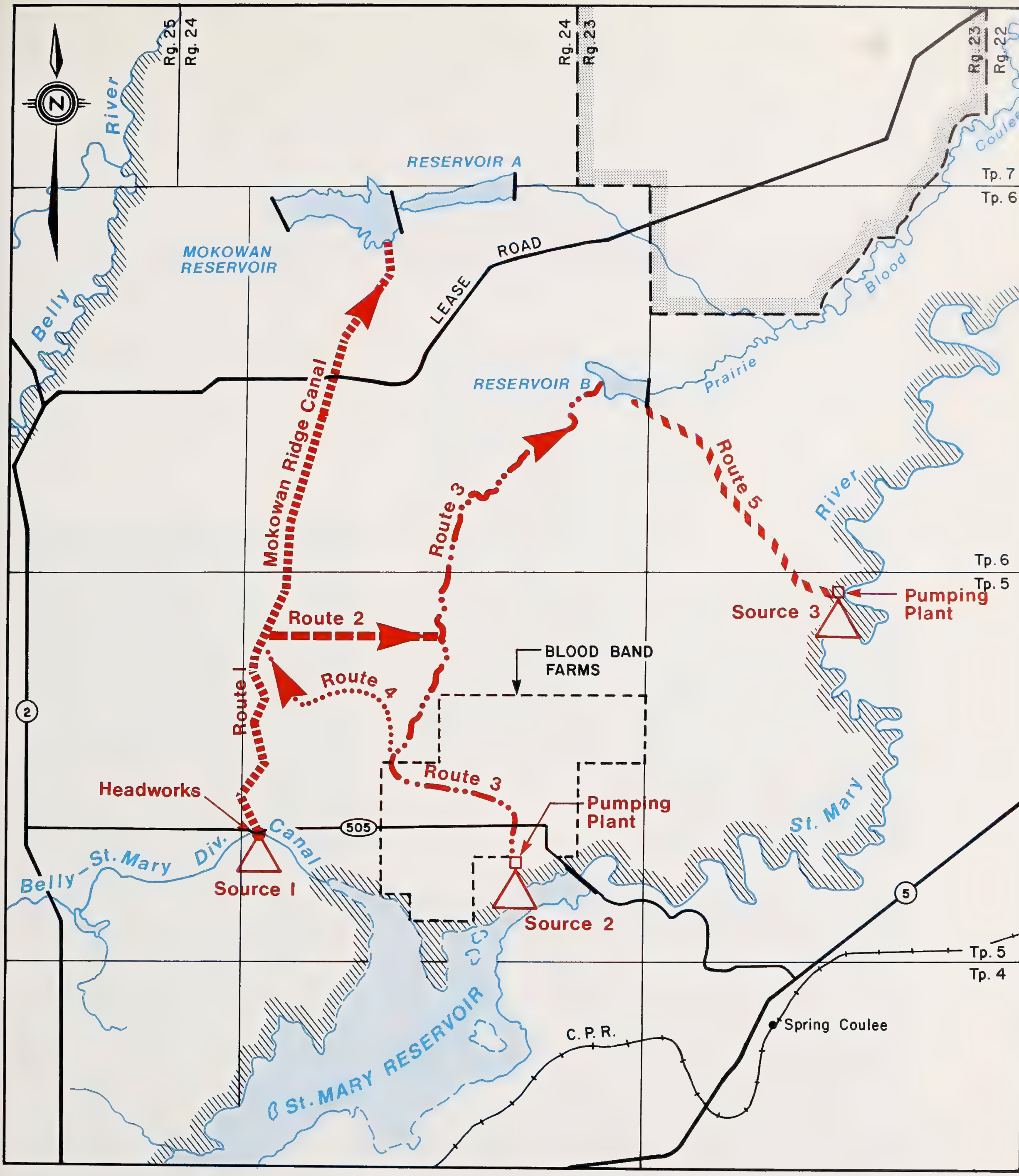
After carefully considering all the advantages and disadvantages of the two alternative routes, the tripartite committee decided that:

1) The study should focus on conveying water to the Big Lease via the Mokowan Ridge Canal.
2) Both pressure conduit and open canal distribution systems should be considered in servicing the irrigable area.
3) Provision should be made to divert water from the Mokowan Ridge Canal to Prairie Blood Coulee for stockwatering and small-scale private irrigation development south of Prairie Blood Coulee.

The committee recognized that the option of conveying water to the Big Lease via Prairie Blood Coulee would remain open if the Mokowan Ridge route proved to be undesirable upon more detailed study.

## B. Conveyance Works

The conveyance works include a combination check and turnout structure on the Belly-St. Mary Diversion Canal, the Mokowan Ridge Canal and the Mokowan Reservoir. These works are shown on Figure 11. Mokowan Reservoir could serve either a closed conduit pressurized distribution system or an open canal system. If an open canal system were selected, there may be some economies in constructing Reservoir A (Figure 10) rather than the Mokowan Reservoir. Reservoir A could be smaller and at a lower elevation than Mokowan Reservoir and it would require only one embankment as opposed to




LEGEND

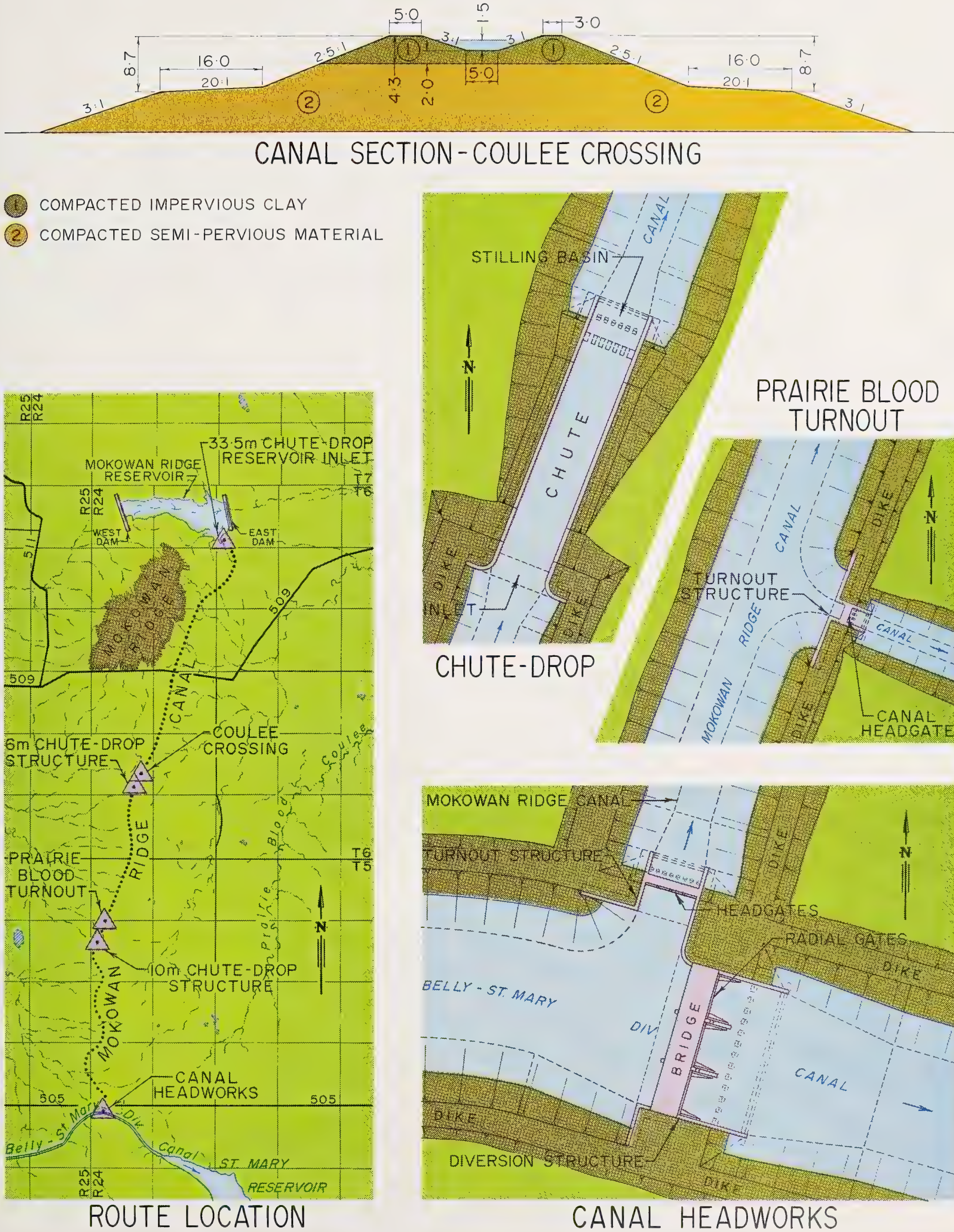
Indian Reserve Boundary

Big Lease Boundary

IRRIGATION ON THE BLOOD INDIAN RESERVE: A FEASIBILITY STUDY

## ALTERNATIVE WATER SOURCES AND CONVEYANCE ROUTES

FIGURE 10




PFRA FIGURE

# MOKOWAN RIDGE CANAL

Figure 11

two for Mokowan Reservoir. For the purposes of this feasibility study, only Mokowan Reservoir is considered in the conveyance works.

The design flow for the conveyance works was selected to be 8.5 $m^3/s$ based on a delivery of 7.9 $m^3/s$ to the irrigable land and an allowance for seepage and other canal and reservoir losses.

The check-turnout structure would be located in NE 7-5-22-4, a site selected to provide the shortest topographically favorable canal route to Mokowan Reservoir. The check structure would have three radial gates that could be operated to achieve the required diversion head at low flows in the Belly-St. Mary Diversion Canal. The turnout structure would have a concrete breastwall equipped with four fabricated steel sliding gates capable of passing the design flow of 8.5 $m^3/s$.

Mokowan Ridge Canal would be an unlined earth canal approximately 16.6 km long from the turnout to Mokowan Reservoir terminating in SE 33-6-24-4. It would have a bottom width of 5.0 m. Geotechnical investigations revealed that seepage would be minimal. To maintain a non-eroding canal gradient, drop structures would be required at two locations along the canal. The vertical drops would be ten metres and six metres. A third drop of 33.5 m would be required where the canal enters the Mokowan Reservoir. Concrete chute drop structures are envisioned at all three locations. A turnout to divert about 0.7 $m^3/s$ to Prairie Blood Coulee would be provided.

The right-of-way for the Mokowan Ridge Canal would be 50 m wide and would require about 215 acres of land of which 91 acres are cultivated. No farmsteads or buidings would be affected. The canal would intersect two secondary highways and three rural roads and would sever about 11 parcels of arable farmland. Bridges would be required to provide access to each severed parcel.

The cost of the canal and associated structures is estimated to be about $5,500,000. (A breakdown of the cost estimate and canal characteristics are given in Table 6.)

The Mokowan Reservoir is located in a former glacial spillway adjacent to Mokowan Ridge. At its full supply level, the reservoir would flood 454 acres of land and store 16,900 $dam^3$ of water. The area flooded is unimproved grazing land; no buildings, roads or utilities would be flooded.

Two earth-fill dams would be required. Foundation conditions are adequate to support the embankments and no special geotechnical problems are anticipated. The design features of the dams and reservoir are shown in Figure 12.

Outlet works would be provided in the east dam only. If an open canal distribution system were used, the outlet structure would consist of a 1500 mm diameter concrete conduit with a gatewell and slide gate. If a pressure water distribution system was used, the outlet works would consist of a 1200 mm diameter steel pipe riparian conduit and a 1650 mm diameter concrete conduit for the main outlet. Both conduits would be regulated by slide gates in gatewells.

The cost of dams and ancillary works is estimated to be $14,200,000 if the canal system is used. The design characteristics of the dams and reservoir and a breakdown of the cost estimate are given in Table 7.

## C. Distribution Works

Preliminary engineering studies were undertaken to prepare plans and cost estimates for both pressure conduit canal systems of water distribution from Mokowan Reservoir to each quarter section of land where irrigation is proposed. Both distribution systems are designed to deliver 7.9 $m^3/s$ to irrigable land. Irrigation development for each system could be carried out over a period of ten years.

### *1. Drainage Network and Access Roads*

Regardless of the type of distribution system that would be constructed in the Big Lease, a drainage network and access roads are required to facilitate irrigation farming.

A drainage network would be required to dewater existing sloughs and ponding or marshy areas and to facilitate the movement of irrigation equipment across the land. Sloughs and ponding areas cover approximately 1780 acres in the Big Lease, some of which are cultivated in dry years. Drainage of sloughs and ponding areas would be accomplished by a network of surface and subsurface drains as shown in Figure 13.

In general, the existing natural drainage channels would serve as trunk drains. Some channel improvements and landscaping would be required to attain uniform gradients and flat side slopes to permit unimpeded movement of sprinkler equipment. The channels would be seeded to grass to prevent erosion. Surface drains would be provided to drain ponding areas less than 0.6 m deep while deeper ponding areas and sloughs would require subsurface drains. Road crossings and canal underdrains would be constructed as required.

The cost of the drainage networks is estimated to be $385,000 for the pressure conduit distribution

system and $505,000 for the canal distribution system.

The existing roads in the Big Lease include the Blood Band Ranch Road, the Lease Road, and several short rural roads of low standard. Many of the road allowances are cultivated. The Big Lease is largely without a roadway network, and additional roads would be required to facilitate irrigation farming on the Big Lease.

A representative road network is shown on Figure 14. North-south roads would be constructed on road allowances and spaced 1.6 km apart. East-west roads would be constructed on road allowances spaced 3.2 km apart. In general, the roads would have a gravel surface and be constructed to Alberta Department of Transportation specifications for rural roads.

The estimated costs for the Big Lease road network for the pressure conduit and canal distribution systems are $2,530,000 and $2,155,000 respectively.

### 2. *Pressure Conduit Distribution System*

The proposed layout of the pressure conduit distribu-tion system is shown on Figure 15. It would involve a 3.3 km canal to convey water from the east embankment of Mokowan Reservoir to the conduit inlet, and a screening plant in Section 11-7-24-4. The conduit inlet is at an elevation high enough to create a positive pressure at all points in the distribution system. The screening plant would have a trash rack, a silt trap and screens to remove floating debris, canal bed load, and suspended material.

Since development of the irrigation project would be phased, a 1950 mm diameter conduit would be installed initially to deliver water to laterals A, B and C. At a later date, a 1650 mm diameter conduit would be installed to deliver water to laterals D, E, F and G. The diameter of the header conduits and each lateral varies along their respective lengths according to the irrigable areas served and pressure. All conduits would be shallow-buried with a minimum cover of one metre above the crown of the pipe.

The operating pressures along the laterals vary from about 83 kPa to 770 kPa. Where operating pressures at the center pivot would be less than 400 kPa, booster pumps would be required at the farm turnout. Booster pumps ranging in size from 1.5 to 23 kW would be required on about 30 percent of the pivots. In other areas, pressure regulating valves would be required at farm turnouts to deliver water to the sprinkler at a constant pressure. Blow-off valves, air vacuum relief valves, turnout fittings and related items would be required at various locations in the system.

The 3.3 km outlet canal would encroach on one farmstead in NE 33-6-24-4 necessitating relocating some buildings and fences. Thirty-seven acres would be required for right-of-ways, of which nine acres are cultivated. One road crossing would be required. The buried pipe distribution system would require minimal land disturbance beyond the construction period.

The estimated cost of the pressure conduit distribution system is $76,500,000. (A breakdown of the cost estimate and the project characteristics are given in Table 8.) The costs of electrically-powered pumps where required are included in the cost of each lateral.

### 3. *Canal Distribution System*

The proposed layout of the canal distribution system is shown on Figure 16. A 14.8 km main canal would originate from the gravity system outlet at the Mokowan East Dam and would deliver water to six lateral canals, one of which would branch into two smaller laterals. The capacity of the header canal at each lateral would be reduced by an amount equivalent to the design capacity of the lateral. Chute drop structures (7 m to 13 m drops) would be required at two locations of steep terrain to maintain proper canal gradient.

Each lateral would be of a size to provide sufficient capacity to meet the highest irrigation demand imposed by the irrigable area it would serve. The capacity would decrease at each farm turnout. Along both the header canal and the laterals, small turnout structures would be provided for each quarter section of irrigation, and would consist of a screened and gated steel pipe to allow water to flow into a pump well. A 34 kW electric motor and pump would supply the required flow at a minimum pressure of 400 kPa to each farm sprinkler.

To avoid creating soil salinity problems adjacent to the canals, buried membrane liners or interceptor drains would be installed along all canal reaches where subsurface soil conditions were judged to require seepage control.

The right-of-way requirements between Mokowan Reservoir and the Big Lease would be 54 acres of which 14 acres are cultivated. Within the Big Lease, the canals would require about 550 acres of land, much of which is cultivated. Three bridges across the header canal would be required to maintain the existing road network and an additional eight crossings would be required for farm access. Seven road bridges and 34 additional crossings

*Table 6*

CHARACTERISTICS AND COSTS OF MOKOWAN RIDGE CANAL

## PROJECT DATA

### CHECK TURNOUT STRUCTURE

| | |
|---|---|
| Check Radial Gates | 3 @ 6.1 m (W) × 2.1 m (H) |
| Net Weir Length | 18.3 m |
| Approach Chute Width | 19.2 m |
| Turnout Slide Gates | 4 @ 1.37 m (W) × 1.37 m (H) |
| Turnout Design Discharge | 8.5 $m^3/s$ |

### PRAIRIE BLOOD COULEE TURNOUT

| | |
|---|---|
| Slide Gates | 2 @ 0.61 m (W) × 0.91 m (H) |
| Chute Width | 1.9 m |
| Design Discharge | 0.7 $m^3/s$ |

### MOKOWAN RIDGE CANAL

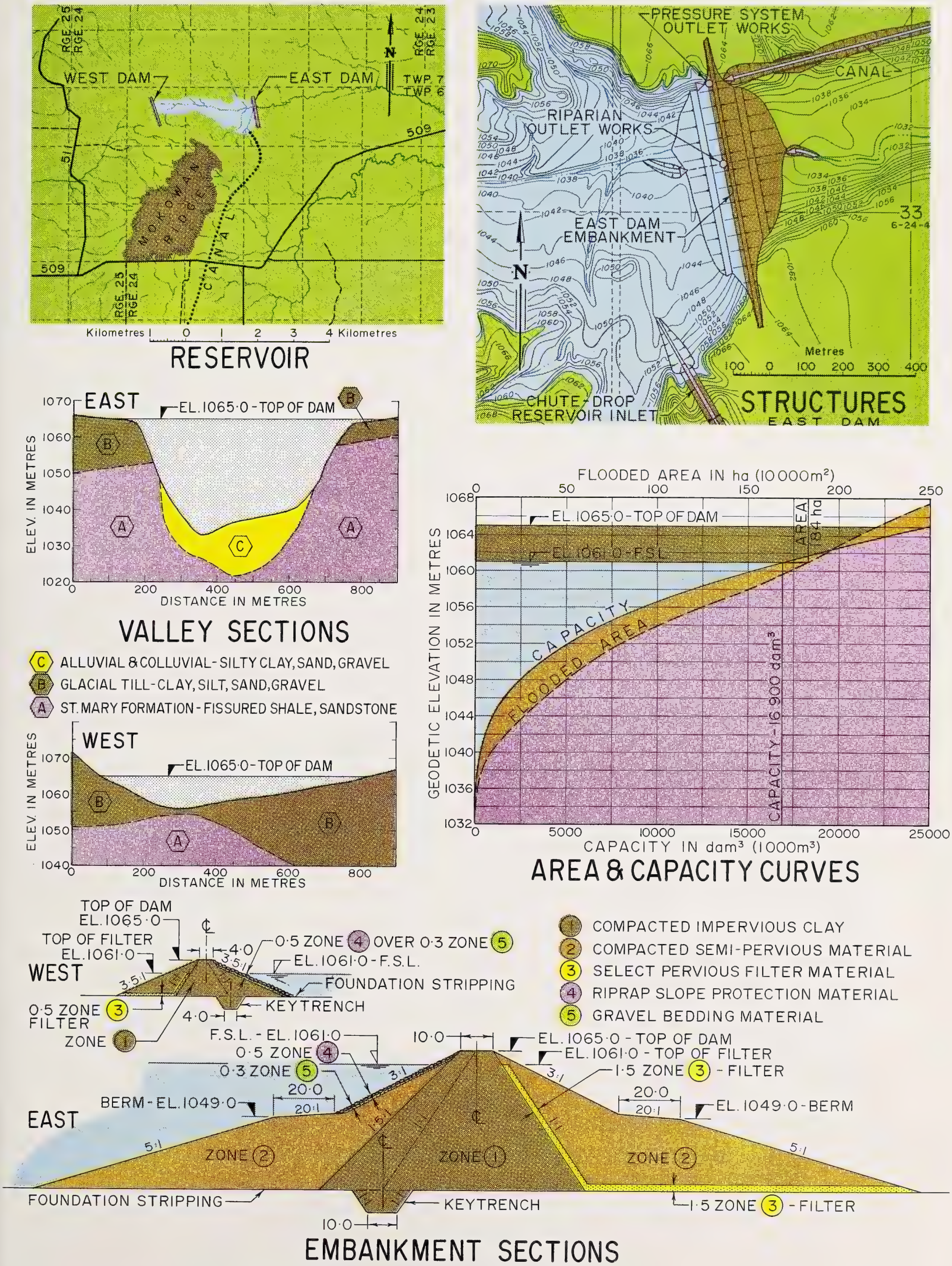
| | |
|---|---|
| Canal Length | 16.6 km |
| Bottom Width | 5.0 m |
| Side Slopes | 2:1 |
| Design Discharge | 8.5 $m^3/s$ |

### DROP STRUCTURES

| | |
|---|---|
| Structure Width | 7.0 m |
| Design Discharge | 8.5 $m^3/s$ |

## COST ESTIMATE SUMMARY

| | |
|---|---|
| Check Turnout Structure | $ 532,000 |
| Canal Excavation | 992,000 |
| Drop Structures | 300,000 |
| Cross Drains | 151,000 |
| Canal Crossing and Bridges | 1,087,000 |
| Prairie Blood Coulee Turnout and Canal | 444,000 |
| Right-of-Way Acquisition | 300,000 |
| Relocation of Utilities | 5,000 |
| Contingencies (25%) | 993,000 |
| Construction Cost | $4,750,000 |
| Engineering (15%) | 720,000 |
| PROJECT COST | $5,500,000 |




PFRA FIGURE

MOKOWAN RIDGE RESERVOIR

Figure 12

*Table 7*

## CHARACTERISTICS AND COSTS OF MOKOWAN RESERVOIR

### PROJECT DATA

#### RESERVOIR

| | |
|---|---|
| Full Supply Level (FSL) | 1,061.0 m |
| Live Storage for Gravity System | 16,900 $dam^3$ |
| Live Storage for Pressure System | 10,140 $dam^3$ |
| Flooded Area at FSL | 185 ha |
| Maximum Depth at FSL | 27.0 m |

#### INLET STRUCTURE

| | |
|---|---|
| Chute Width | 7.0 m |
| Structure Length | 176.9 m |

#### OUTLET WORKS (EAST DAM) FOR A GRAVITY SYSTEM

| | |
|---|---|
| Diameter of Conduit | 1,500 mm |
| Conduit Length | 300.0 m |
| Design Outflow | 8.5 $m^3/s$ |

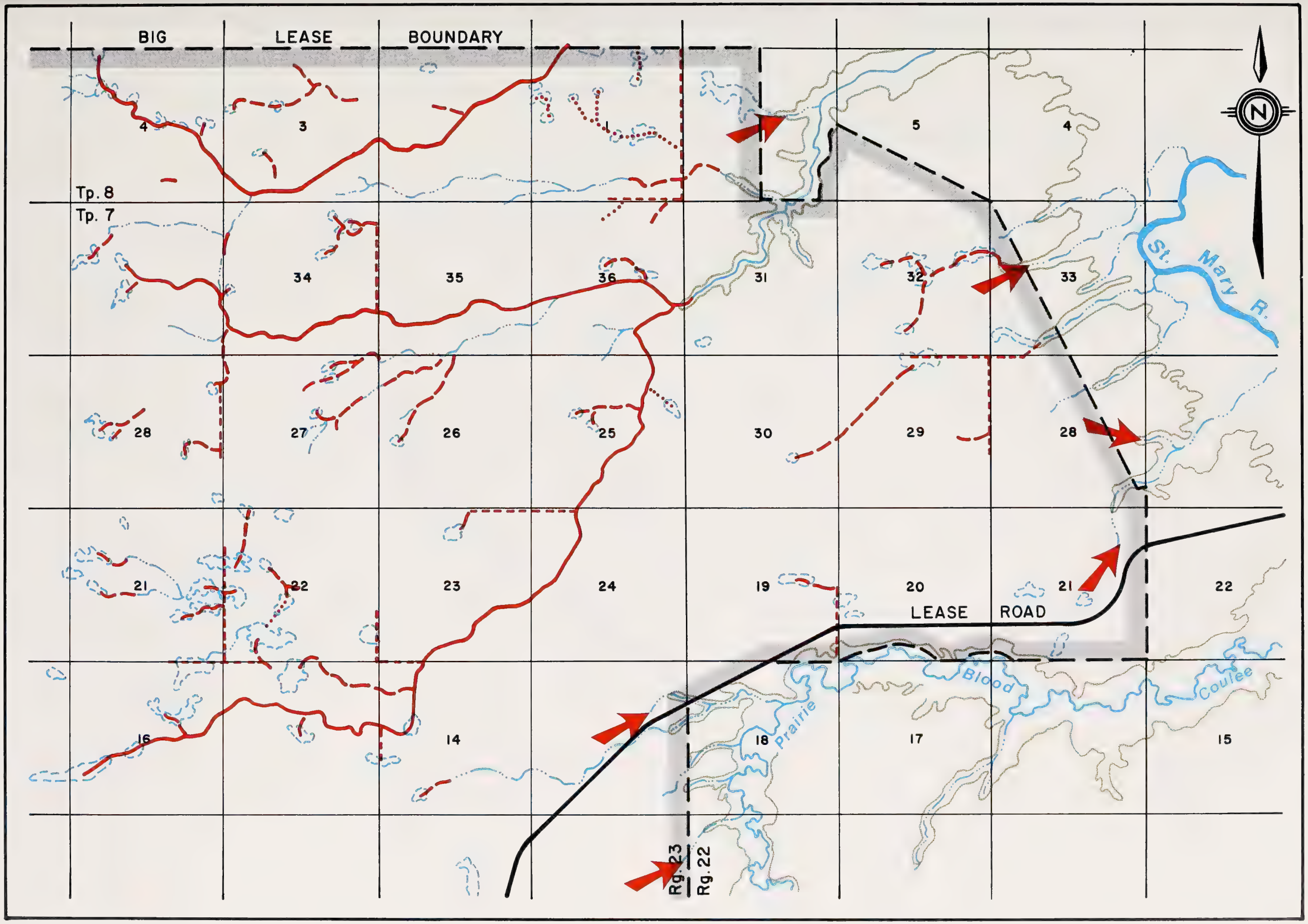
| EMBANKMENTS | East Dam | West Dam |
|---|---|---|
| Top of Dam Elevation | 1,065.0 m | 1,065.0 m |
| Crest Length | 600 m | 700 m |
| Maximum Height | 31 m | 8 m |
| Top Width | 10.0 m | 4.0 m |

#### OUTLET WORKS (EAST DAM) FOR A PRESSURE SYSTEM

| | Main Outlet | Riparian |
|---|---|---|
| Conduit Diameter | 1,650 mm | 1,600 mm |
| Conduit Length | 82.0 m | 278.0 m |
| Design Outflow | 8.5 $m^3/s$ | |

### COST ESTIMATE SUMMARY

| | Gravity System | Pressure System |
|---|---|---|
| East Dam | $ 7,265,600 | $ 7,265,600 |
| West Dam | 674,500 | 674,500 |
| Reservoir Inlet Structure | 699,000 | 699,000 |
| Outlet Works | 700,900 | 261,900 |
| Riparian | Not Needed | 295,000 |
| Access Roads | 165,000 | 165,000 |
| Right-of-Way Acquisition | 350,000 | 350,000 |
| Contingencies (25%) | 2,495,000 | 2,465,000 |
| Construction Cost | $12,350,000 | $12,176,000 |
| Engineering | 1,850,000 | 1,824,000 |
| PROJECT COST | $14,200,000 | $14,000,000 |




LEGEND

Landscaped Drain (Grassed Channel)

Surface Drain (Landscaped - 5:1 Sideslopes)

Boundary Ditch (2:1 Sideslopes)

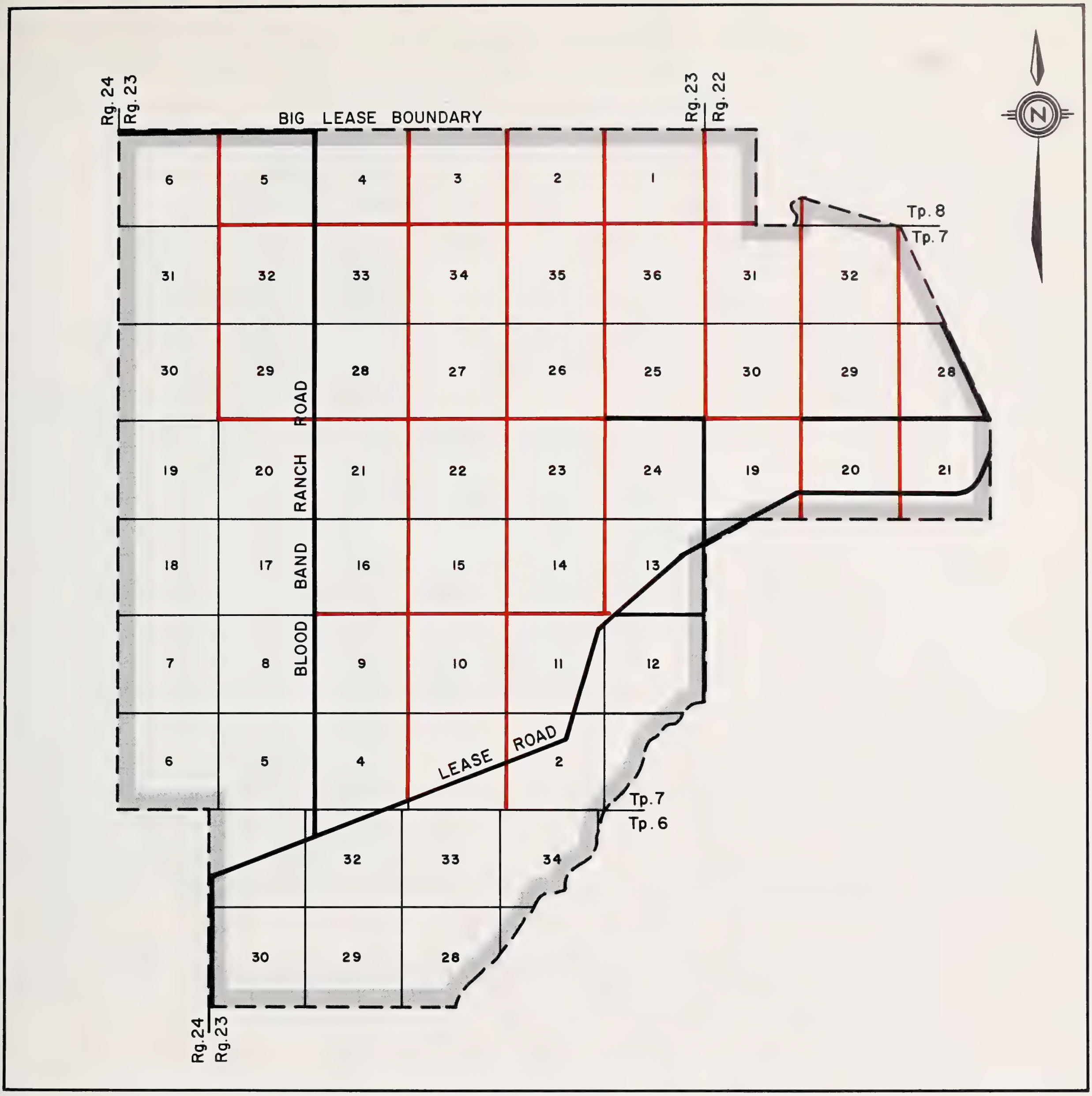
Subsurface Drain (Buried Conduit)

Lateral End & Tailout

IRRIGATION ON THE BLOOD INDIAN RESERVE:
A FEASIBILITY STUDY

## DRAINAGE NETWORK LAYOUT

FIGURE 13




LEGEND

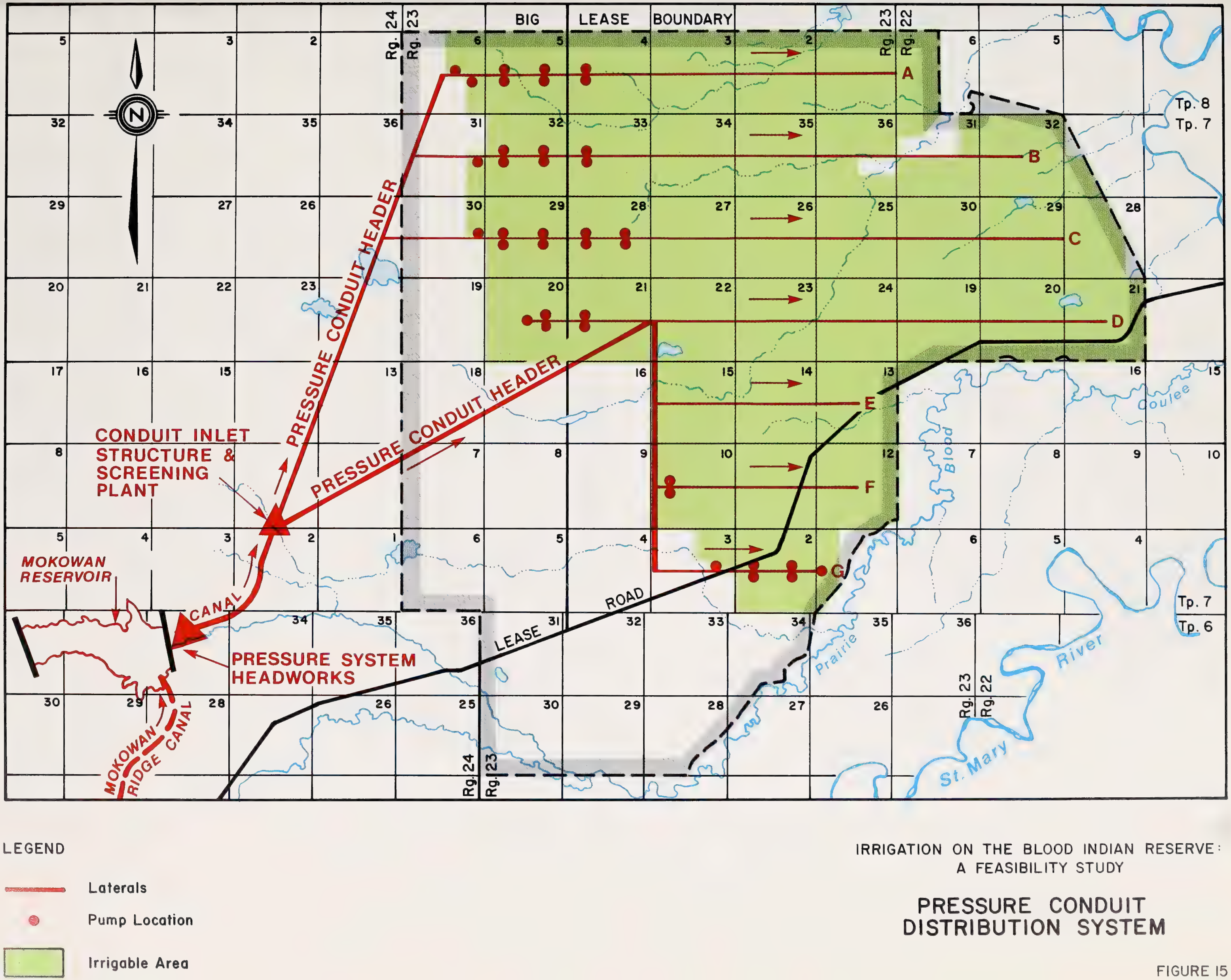
Existing Road

Proposed Road

IRRIGATION ON THE BLOOD INDIAN RESERVE:
A FEASIBILITY STUDY

## ACCESS ROAD NETWORK

FIGURE 14




IRRIGATION ON THE BLOOD INDIAN RESERVE:
A FEASIBILITY STUDY

## PRESSURE CONDUIT DISTRIBUTION SYSTEM

FIGURE 15

*Table 8*

## CHARACTERISTICS AND COSTS OF PRESSURE CONDUIT DISTRIBUTION SYSTEM

### PROJECT DATA

#### OUTLET CANAL

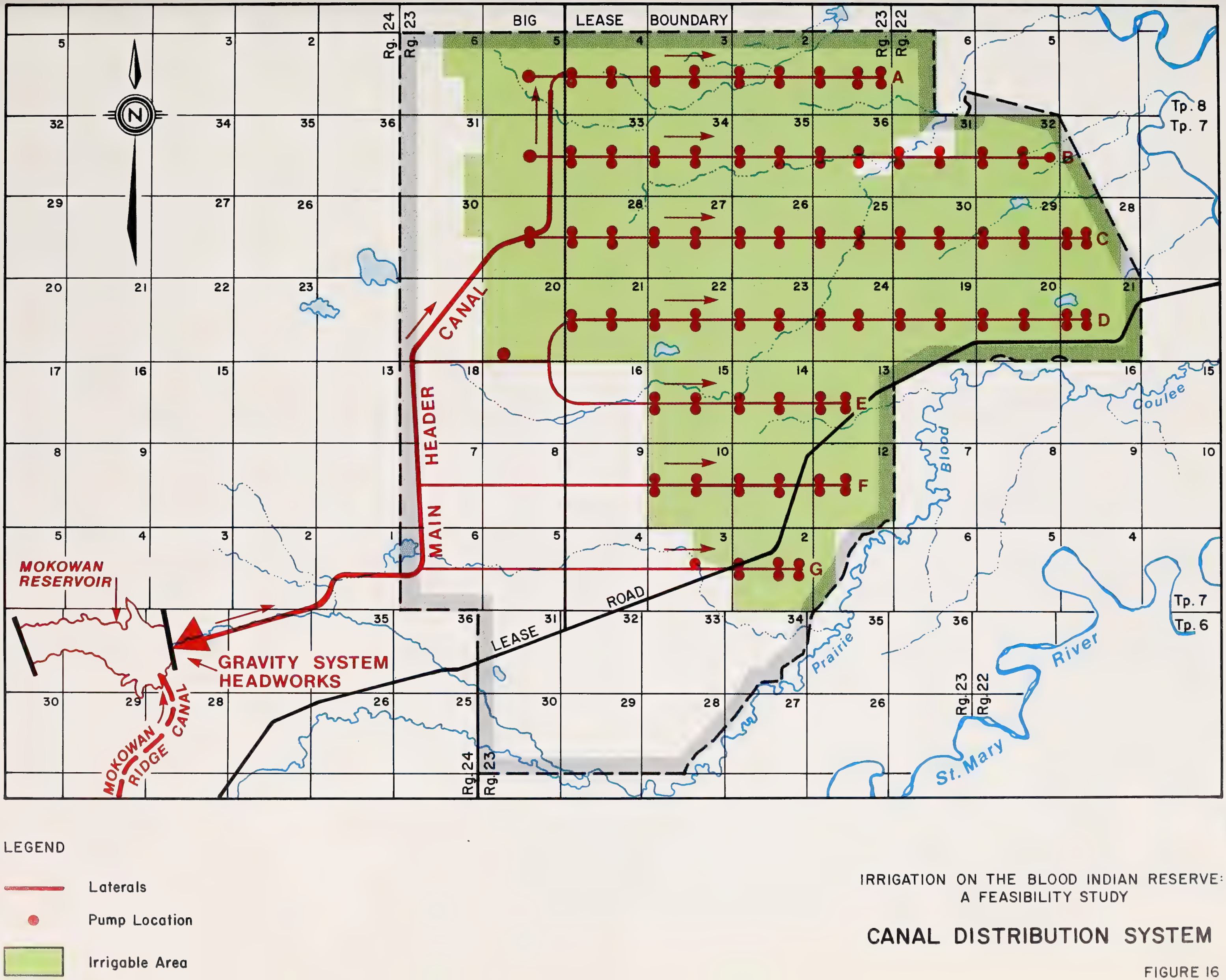
| | |
|---|---|
| Canal Length | 3.3 km |
| Bottom Width | 5.0 m |
| Side Slopes | 2:1 |
| Design Discharge | 8.5 $m^3/s$ |

#### PRESSURE CONDUIT LATERALS

| Lateral | Length | Diameters | Turnouts |
|---|---|---|---|
| A | 8.3 km | 1,100 to 300 mm | 24 |
| B | 12.3 km | 1,200 to 300 mm | 30 |
| C | 13.9 km | 1,200 to 300 mm | 33 |
| D | 11.6 km | 1,100 to 300 mm | 31 |
| E | 4.5 km | 750 to 300 mm | 12 |
| F | 4.5 km | 750 to 300 mm | 12 |
| G | 3.6 km | 500 to 250 mm | 7 |

### COST ESTIMATE SUMMARY

| | |
|---|---|
| Outlet Canal | $ 235,200 |
| Wasteway | 49,000 |
| Screening Plant and Conduit Inlet | 233,000 |
| 1,950 mm diameter Conduit and Installation | 12,563,000 |
| 1,650 mm diameter Conduit and Installation | 13,002,000 |
| Lateral A | 3,459,000 |
| Lateral B | 5,446,000 |
| Lateral C | 6,527,000 |
| Lateral D | 4,714,000 |
| Lateral E | 1,170,000 |
| Lateral F | 1,397,000 |
| Lateral G | 725,000 |
| Drainage Works | 385,000 |
| Bridge and Canal Crossings | 199,800 |
| Roads | 2,530,000 |
| Right-of-Way Acquisition | 290,000 |
| Relocation of Utilities | 5,000 |
| Contingencies (25%) | 13,614,000 |
| Construction Cost | $66,544,000 |
| Engineering (15%) | 9,956,000 |
| PROJECT COST | $76,500,000 |




IRRIGATION ON THE BLOOD INDIAN RESERVE:
A FEASIBILITY STUDY

## CANAL DISTRIBUTION SYSTEM

FIGURE 16

would be required across the laterals within the Big Lease.

The canal distribution system will cost an estimated $32,300,000. (A breakdown of the estimated cost and the project characteristics are given in Table 9.) The costs of electrically-powered pumps are included in the cost of each lateral.

## D. Cost Summary for Conveyance and Distribution Facilities

The project cost summary for Mokowan Ridge Canal, Mokowan Reservoir and the two separate water distribution systems are as follows:

| Pressure Conduit Distribution | |
|---|---|
| Mokowan Ridge Canal | $ 5,500,000 |
| Mokowan Reservoir | 14,000,000 |
| Distribution Conduits and Pumps | 76,500,000 |
| Total Project Costs | $96,000,000 |

| Canal Distribution | |
|---|---|
| Mokowan Ridge Canal | $ 5,500,000 |
| Mokowan Reservoir | 14,200,000 |
| Distribution Canal and Pumps | 32,300,000 |
| Total Project Costs | $52,000,000 |

The cost of the distribution systems includes the costs of a road network, drainage network and pumps. They do not include the cost of an electrical grid to provide three-phase power to the pumps. The construction costs of the grid are an integral part of the utility rate schedules and hence, the annual costs, both of which are considered in the economic analysis. With this exception, both systems include all capital costs to provide water under pressure to the farm gate. Engineering costs and contingencies are also included for both systems.

The costs outlined above should be treated as preliminary and subject to revision pending a more detailed study of design flows, the distribution system layout and design, and geotechnical factors. These preliminary costs are sufficiently accurate to establish the feasibility of irrigating on the Big Lease. At the next level of study of this project, more detailed analyses of on-farm irrigation systems, the operation of Mokowan Reservoir and the security of supply would be required. This could possibly lower the design flow and reduce the costs for the conveyance and distribution systems. Also, in this feasibility study, designs and cost estimates were limited to one arrangement of canals and pressure conduits for each distribution system, and the provision of water to each quarter section of land. There are other arrangements of canals and conduits and various on-farm options that may reduce distribution costs. While this study presents sufficient information to establish the feasibility of the project, the next level of study should consider other practical alternatives that may have technical and economic merits.

The costs of individual farm sprinklers and other on-farm costs were not considered in this engineering study. On-farm costs, energy and other annual costs would be different for the two distribution systems and are considered in detail in the economic analysis.

*Table 9*

## CHARACTERISTICS AND COSTS OF CANAL DISTRIBUTION SYSTEM

### PROJECT DATA

#### MAIN HEADER CANAL

| | |
|---|---|
| Canal Length | 14.8 km |
| Bottom Width | 5.0 m |
| Side Slopes | 2:1 |
| Design Discharge | 8.5 $m^3/s$ |

#### GRAVITY CANAL LATERALS

| Lateral | Length | Turnouts |
|---|---|---|
| A | 6.5 km | 18 |
| B | 10.2 km | 25 |
| C | 11.8 km | 30 |
| D | 11.8 km | 28 |
| E | 6.5 km | 12 |
| F | 9.0 km | 12 |
| G | 8.5 km | 7 |

### COST ESTIMATE SUMMARY

| | |
|---|---|
| Main Header Canal | $ 3,332,000 |
| Lateral A | 2,188,000 |
| Lateral B | 2,200,000 |
| Lateral C | 2,712,000 |
| Lateral D | 2,896,000 |
| Lateral E | 1,240,000 |
| Lateral F | 896,000 |
| Lateral G | 613,000 |
| Drainage Works | 505,000 |
| Roads | 2,155,000 |
| Bridge and Canal Crossings | 2,816,000 |
| Right-of-Way Acquisition | 740,000 |
| Relocation of Utilities | 5,000 |
| Contingencies (25%) | 5,872,000 |
| Construction Cost | $28,170,000 |
| Engineering (15%) | 4,130,000 |
| PROJECT COST | $32,300,000 |

# CHAPTER V: ECONOMICS

*The Blood Tribe understands the promise of irrigation: better crop yields, higher profits, more jobs on the reserve, the development of secondary industries, and greater independence.*

The economics component examined the economic feasibility of developing an irrigation project in the Big Lease area. Annual expenditures for engineering works and on-farm costs, and the benefits attributable to irrigation farming were estimated; benefit-cost ratios were determined; a sensitivity analysis was conducted; and the distribution of benefits to the region, province and nation were estimated.

The study was carried out by Underwood McLellan Limited and Marv Anderson and Associates Limited under direction of Alberta Environment. A detailed account of methodology and results is given in Supplement 4.

## A. Conveyance and Distribution System Costs

The conveyance and alternative distribution systems would be constructed over a 14-year period; three years for the Mokowan Ridge Canal and Mokowan Reservoir plus an additional 11 years for the distribution system. A distribution of the capital and annual operation and maintenance costs for the conveyance and distribution works for the life of the project is summarized in Table 10. Operation and maintenance costs were taken as one percent of the cumulative capital costs for the conveyance works and canal distribution system and 0.2 percent of the

cumulative capital costs for the pressure conduit distribution system.

The cost of installing the electrical grid for the project is an integral part of rate schedules, and trade-offs can be made between the customer share of capital and investment and seasonal energy charges. The various options were evaluated in an economic analysis, and for both distribution systems there was considerable saving in paying higher installation costs in return for lower seasonal charges for electricity.

About 30 percent of the pivots in the pressure conduit system would require booster pumps. All pivots in the canal system would require pumps. Annual electricity costs would be $2.00 per acre for the pressure conduit distribution system (assuming costs are evenly distributed among all center pivots) and $10.00 per acre for the canal distribution system. These costs include the cost of propelling the center pivots. The costs of electrical installation and energy are given in Table 10 for an assumed development scenario discussed later in this chapter.

The costs for the first 14 years are considerably higher for the pressure conduit distribution system primarily due to the high cost of the pipes, however, from year 15 to year 65 the pressure system has much lower operation and maintenance and electricity costs.

## B. Farm Costs

Farm units sizes of 2560 acres and 640 acres were considered in the economic analysis. A crop mix of barley, wheat, alfalfa and canola was considered for the larger farm units. Specialty crops of canning corn, canning peas, dry beans and canola were included in various cropping scenarios for the smaller farm units. (The crop mixes assumed for the two farm unit sizes are given in Table 11.) A dryland rotation of 75 percent spring wheat and 25 percent summerfallow was used in the analysis to account for non-irrigated corners of quarter section pivots.

The total fixed and variable on-farm costs were estimated for each farm unit and for each crop mix scenario for both irrigation and dryland farming. The total cost of farm equipment and storage was estimated to be $686 per acre for the 2560 acre farm units and $853 per acre for a typical 640 acre farm unit. (A list of equipment and a cost breakdown are given in Supplement 4.) Annual fixed costs included depreciation, and the annual costs of equipment insurance and storage, and are independent of the acreages of crops produced. Variable costs are dependent on the acreage of each crop, and include fuel, lubricants, repairs, seed, fertilizer and chemicals, crop insurance and interest on operating capital. Labor and management costs, water charges, land costs and interest on invested capital have not been included in the economic analysis. A summary of annual on-farm costs per acre in 1981 dollars for each farm unit is given in Table 12.

Dryland farm costs were estimated for 2560 and 640 acre equivalent farms to parallel irrigated farm costs. Cropping patterns of cereals, oilseeds and summerfallow were considered in the ratios documented in the agronomy component. The resulting variable and fixed costs are given in Table 12.

## C. Benefits

The direct benefits from irrigation farming on the Blood Indian Reserve were considered to include crop returns, livestock production, income stability, and employment opportunities during the construction period.

### 1. *Crop Returns*

Produce prices and yields determine gross crop returns. Traditionally, agriculture produce prices have been dependent on world markets and have been highly variable. The average real price over the past ten years, adjusted to the 1981 dollar value by the consumer price index, was selected as the basis for pricing the agricultural products. Level II yields, as determined in the agronomy component, were used to compute gross returns, and were used as a basis for comparison only; they should not be expected to occur uniformly over the life of the project. Expected gross crop returns based on these estimated price and yield levels are given in Table 13. The gross returns for various farm sizes and crop mixes for irrigated and dryland farms are given in Table 14.

Net crop returns (gross returns minus total costs) and net value added were computed for each farm unit size and crop mix. Net returns to labor, management, water and land are given in Table 14. The value added attributable to irrigation was computed as the difference between net returns to irrigation farms and the net returns to dryland farms.

### 2. *Livestock Benefits*

Livestock is an important component of the agricultural economy of the region. An integrated irrigated crop-livestock operation could convert forage production into a higher payoff combination, since livestock production is directly related to the availability of adequate and reliable forage supplies. Multipliers that relate the value added in livestock production to the value added in crop production for various crop types (Marv Anderson and Associates

*Table 10*

## TOTAL ANNUAL COSTS FOR CONVEYANCE, DISTRIBUTION AND ELECTRICAL WORKS
(1981 Dollars × 1000)

| | Pressure Conduit Distribution System | | | | | | Canal Distribution System | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capital Costs | | | | | | | Capital Costs | | | | | |
| Year | Conveyance System | Pressure Conduit Distribution | Operation and Maintenance | Electrical Grid | Pump Electricity | Total Cost | Conveyance System | Canal Distribution | Operation and Maintenance | Electrical Grid | Pump Electricity | Total Cost |
| 1 | 2,575 | 600 | — | — | — | 3,175 | 2,640 | 500 | — | — | — | 3,140 |
| 2 | 9,000 | 600 | — | — | — | 9,600 | 10,000 | 500 | — | — | — | 10,500 |
| 3 | 8,000 | 6,560 | — | — | — | 14,560 | 8,000 | 500 | — | — | — | 8,500 |
| 4 | | 20,219 | — | 220 | — | 20,439 | | 8,390 | — | 302 | — | 8,692 |
| 5 | | 6,900 | 252 | 52 | 5 | 7,209 | | 3,000 | 305 | 75 | 26 | 3,406 |
| 6 | | 3,900 | 266 | 29 | 10 | 4,205 | | 2,800 | 335 | 69 | 51 | 3,255 |
| 7 | | 4,400 | 274 | 26 | 15 | 4,715 | | 1,900 | 363 | 37 | 77 | 2,377 |
| 8 | | 8,950 | 282 | 4 | 18 | 9,254 | | 1,926 | 382 | 55 | 90 | 2,453 |
| 9 | | 10,232 | 300 | 15 | 23 | 10,570 | | 2,301 | 402 | 60 | 115 | 2,878 |
| 10 | | 5,580 | 321 | 120 | 28 | 6,049 | | 2,600 | 425 | 117 | 141 | 3,283 |
| 11 | | 4,855 | 332 | 178 | 33 | 5,398 | | 2,197 | 451 | 89 | 166 | 2,903 |
| 12 | | 2,000 | 342 | 36 | 36 | 2,414 | | 2,804 | 473 | 143 | 179 | 3,599 |
| 13 | | 1,542 | 346 | — | 41 | 1,929 | | 1,087 | 501 | 32 | 205 | 1,825 |
| 14 | | 232 | 349 | 7 | 45 | 633 | | 400 | 511 | 17 | 227 | 1,155 |
| 15-65 | | | 349 | | 50 | 399 | | | 515 | | 250 | 765 |

*Table 11*

CROP MIX SCENARIOS

| Crop Type | 2560 Acre Farm Units | | 640 Acre Farm Units | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mix A[1] | | Mix B[2] | | Mix C[3] | |
| | Pivots | % of Area | Pivots | % of Area | Pivots | % of Area | Pivots | % of Area |
| Alfalfa | 6 | 31 | 1 | 21 | 1 | 21 | 1 | 21 |
| Canola | 4 | 21 | 1 | 21 | | | | |
| Spring Wheat | 4 | 21 | 1 | 21 | 0.5 | 10 | 1 | 21 |
| Barley | 2 | 10 | 1 | 21 | 0.5 | 10 | 1 | 21 |
| Canning Peas | | | | | 1 | 21 | | |
| Canning Corn | | | | | 1 | 21 | | |
| Dry Beans | | | | | | | 1 | 21 |
| Spring Wheat (dryland) | | 13 | | 13 | | 13 | | 13 |
| Summerfallow (dryland) | | 4 | | 4 | | 4 | | 4 |

[1] Mix A — Canola specialty
[2] Mix B — Canning peas and corn specialty
[3] Mix C — dry beans specialty

*Table 12*

ANNUAL ON-FARM COSTS PER ACRE[1]

| | 2560 Acre Farm | 640 Acre Farm | | |
|---|---|---|---|---|
| | | Mix A | Mix B | Mix C |
| Irrigation | | | | |
| Variable Costs | $ 88.73 | $ 96.66 | $ 123.45 | $ 91.69 |
| Fixed Costs | 50.47 | 62.59 | 67.64 | 62.59 |
| Totals | 139.20 | 159.25 | 191.09 | 154.28 |
| Dryland | | | | |
| Variable Costs | 53.54 | | 54.65 | |
| Fixed Costs | 28.14 | | 34.90 | |
| Totals | 81.68 | | 89.55 | |

[1] Interest in invested capital and labor costs are not included in this economic anaylsis, hence, above costs may be lower than actual on-farm costs as determined in a cash flow or financial analysis.

*Table 13*

EXPECTED GROSS CROP RETURNS

| Crop | Yield per Acre[1] | Unit Price (1981 dollars) | Gross Return per Acre |
|---|---|---|---|
| Irrigation | | | |
| Spring Wheat | 60.0 bu | $ 5.53 | $ 332 |
| Barley | 100 bu | 3.19 | 319 |
| Canola | 49.6 bu | 8.94 | 443 |
| Alfalfa | 4.17 Ton | 69.19 | 289 |
| Sweet Corn | 7.25 Ton | 120 | 879 |
| Green Peas | 1.25 Ton | 287 | 359 |
| Dry Beans | 28.0 bu | 12 | 336 |
| Dryland | | | |
| Spring Wheat | 26.0 bu | 5.53 | 144 |
| Canola | 15.9 bu | 8.94 | 142 |

[1] For metric equivalent see Table 4

*Table 14*

CROP RETURNS PER ACRE FOR VARIOUS FARM UNITS
(1981 Dollars)

| | 2560 Acre Farm Unit | 640 Acre Farm | | |
|---|---|---|---|---|
| | | Mix A[3] | Mix B[3] | Mix C[3] |
| Irrigation | | | | |
| Gross Returns | 300.26 | 303.36 | 398.33 | 281.29 |
| Total Costs | 139.20 | 159.25 | 191.09 | 154.28 |
| Net Returns | 161.06 | 144.11 | 207.24 | 127.01 |
| Dryland[1] | | | | |
| Gross Returns | 109.96 | | 109.91 | |
| Total Costs | 81.68 | | 89.55 | |
| Net Returns | 28.28 | | 20.36 | |
| Net Value Added[2] | 132.78 | 123.75 | 186.88 | 106.65 |

[1] Based on cropping pattern of 65.9% cereals, 10.7% oilseeds, 23.4% summerfallow.

[2] Attributable to converting from dryland farming to irrigation farming.

[3] For crop mix refer to Table 11.

Limited, 1978) were used to determine net returns to livestock production that could be attributed to irrigation farming on the Big Lease. For the crop mixes envisioned on the Big Lease, the net value added to livestock production is estimated to be about 33 percent of the net value added to crop production.

### 3. *Income Stability*

Irrigation farming results in more stable incomes to producers since yield reductions due to shortages in moisture can be virtually eliminated. A value for income stability was computed on the basis of the approximate cost of premiums for an insurance program that would provide an equivalent level of income stability. The annual premium cost was estimated to be about $2.94 per acre, which was applied to the developed acreage to provide an estimate of annual stability benefits.

### 4. *Regional Construction Benefits*

Short term benefits accrue to the region from the payment of salaries and wages to local construction personnel and from the purchase of some local construction materials for the project.

Based upon studies of other proposed irrigation projects in southern Alberta (Marv Anderson and Associates Limited, 1977) labor and materials were estimated to be 38 and 62 percent respectively of the capital cost of the proposed project. With regard to labor costs, it was assumed that 75 percent of total regional labor costs would be disposable income, and that 75 percent of it would be spent within the region. With regard to materials, it was estimated that about ten percent of the materials would be purchased within the region and that the gross value-added associated with this purchase would be 25 percent.

The construction costs of the project are dependent upon the type of distribution system used, and are significantly higher for the closed conduit system than for the canal system because of higher material and labor costs. The annual regional construction benefits for each distribution system were estimated for the 14-year development period.

### 5. *Total Benefits*

In the first four years of the life of the irrigation project the conveyance and distribution systems would be constructed. Irrigation would not begin until the fifth project year. A scenario for irrigation development over 11 years is presented in Table 15. The scenario uses the 2560 and 640 acre farm unit sizes and approximates the representative crop mix suggested in the agronomy component.

The estimated direct annual benefits to the project through crop returns, livestock operations, income stability and employment during the construction period are listed in Table 15.

## D. Economic Analysis

The project benefit and project costs were compared to determine the overall economic and socio-economic feasibility of the proposed irrigation development. Two specific criteria were used as indications of economic feasibility:

1) $$\frac{\text{Benefit}}{\text{Cost}} = \frac{\text{Sum of Discounted Direct Net Benefits}}{\text{Sum of Discounted Direct Net Costs}}$$

2) Net Present Value = Sum of Discounted Direct Net Benefits minus Sum of Discounted Direct Net Costs

To be economically feasible, the benefit-cost ratio (B/C) must exceed 1.0 and the Net Present Value (NPV) must be positive.

All costs and benefits in Tables 10 and 15 are expressed in 1981 dollars. Future payments were discounted to their present value using a base real discount rate of six percent. The economic life of the project was assumed to be 65 years, including the construction period.

The streams of direct annual costs and benefits given in Tables 10 and 15 were discounted to their present value and compared. The results are as follows:

| | Pressure Conduit Distribution System | Canal Distribution System |
|---|---|---|
| Direct B/C | 0.82 | 1.13 |
| Direct NPV | ($13,435,000) | $6,431,000 |

From this analysis, the pressure conduit system cannot be justified on the basis of direct economic benefits; the canal system can. The apparent difference between the two systems results from high material costs for the pressure conduit system. The reduced pumping costs of the pressure conduit system do not balance out the large initial capital cost. However, the pressure conduit alternative should not be ruled out on the basis of this preliminary analysis. Upon further study, design refinements may lower the cost of the pressure system to the extent that, with consideration of its many intangible benefits, it may prove to be the more practical alternative. The next study phase of this project should consider both distribution alternatives.

The direct costs and benefits ignore any spinoff economic activities and secondary benefits that the project would generate in the region. Secondary benefits are those benefits that would accrue to the project other than direct benefits, and would include any benefits to supply and service sectors of the economy and to secondary process industries. The associated costs are equal to the total value of the goods and services used to produce the secondary benefits. The difference between secondary benefits and costs is the net beneficial effect of secondary activities accruing from the project over and above the direct benefits.

To derive the total (direct and secondary) benefit-cost ratios, income multipliers compiled from a number of studies pertinent to the agricultural industry in Alberta and Canada (Marv Anderson and Associates; 1978) were used to adjust the direct net benefits upward. The multipliers used are as follows:

| | Crop Production | Livestock Production |
|---|---|---|
| Region | 1.48 | 1.77 |
| Province | 1.63 | 1.98 |
| Canada | 2.10 | 2.55 |

These multipliers should be viewed as being representative of the project rather than as exact values distinctive to this project.

Direct and secondary benefit-cost ratios and net present values were computed for the region, province and nation as shown in Table 16. In this context, all benefit-cost ratios exceed 1.0 and all net present values are positive, hence, both distribution systems could be considered economically feasible. This conclusion is valid only if under-utilized resources in the Canadian economy can be mobilized if the project is implemented. Given economic conditions prevailing in the summer of 1982 and the persistently high level of unemployment on the reserve, it is felt that the direct and secondary benefit-cost ratios given in Table 16 are better indicators of the economic viability of the irrigation proposal than are the direct benefit-cost ratios.

## E. Sensitivity Analysis

A sensitivity analysis was carried out to re-examine the important underlying assumptions in the economic analysis and to identify which variables have the greatest effect on the results of the analysis. The assumptions used in the basic analysis were examined in turn, and variations were tested to determine their effects on the direct benefit-cost ratios. The results are shown in Table 17 and are discussed below.

### 1. *Crop Yields*

Yields can vary among projects and among farms due to both physical and managerial factors. Good management would be particularly important on the Big Lease where soil conditions require careful control of water application rates and scheduling.

Crop yields 20 percent higher and lower than the base case were tested. A 20 percent reduction approximates Level I crop yields which are the yields presently being obtained on irrigated land near the reserve, while a 20 percent increase would approximate yields obtained under experimental conditions. Since the incremental income resulting from increased yield is the primary benefit of irrigation development, the benefit-cost ratio is very sensitive to yield changes. A 20 percent variation in yield changes the direct benefit-cost ratio by about 30 percent. A similar variation in benefit-cost ratio can be expected for a 20 percent change in agricultural product prices.

### 2. *Livestock Benefits*

The sensitivity and analysis determined the extent to which livestock benefits would contribute to the economic feasibility of the project. If zero livestock production benefits were assumed, the benefit-cost ratio would be reduced by about 20 percent.

### 3. *Discount Rates*

The real discount rate was varied from six percent to four percent and eight percent, a relative change of ±33 percent. At a real discount rate of four percent, the benefit-cost ratio increases by about 35 percent and both options become economically viable based on direct benefits alone. At a real discount rate of eight percent the benefit-cost ratios decrease by 20 percent. Hence, the economic analysis is highly sensitive to discount rate.

### 4. *Construction Costs*

Construction costs were increased by 25 percent over base case costs in the sensitivity analysis. The benefit-cost ratio was reduced by about 14 percent for both distribution alternatives, indicating that the viability of the project is sensitive to construction cost increases. These costs must remain in line with other costs and agricultural product prices for the project to maintain its economic viability.

### 5. *Cropping Patterns*

The base case crop mix scenario was 40 percent cereals, 40 percent forage, 15 percent oilseeds and five percent specialty crops. Two alternative cereal, forage and specialty crop mix scenarios were tested

*Table 15*

SUMMARY OF DIRECT BENEFITS

| | Development | | Benefits (Net Value Added — $1000) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Construction[3] | | Totals | |
| Year | Acres Added | Total Acres | Crop Returns | Livestock Production | Income Stability | Closed Conduit | Canal | Closed Conduit | Canal |
| 1 | | | | | | 731 | 723 | 731 | 723 |
| 2 | | | | | | 2210 | 2417 | 2210 | 2417 |
| 3 | | | | | | 3351 | 1956 | 3351 | 1956 |
| 4 | | | | | | 4654 | 1931 | 4654 | 1931 |
| 5 | 2560 | 2560 | 340 | 113 | 8 | 1588 | 691 | 2049 | 1152 |
| 6 | 2560 | 5120 | 680 | 225 | 15 | 898 | 645 | 1818 | 1565 |
| 7 | 2560 | 7680 | 1020 | 338 | 23 | 1013 | 437 | 2394 | 1818 |
| 8 | 1280[1] | 8960 | 1259 | 411 | 26 | 2060 | 443 | 3756 | 2139 |
| 9 | 2560 | 11520 | 1599 | 524 | 34 | 2355 | 530 | 4512 | 2687 |
| 10 | 2560 | 14080 | 1939 | 637 | 41 | 1284 | 598 | 3901 | 3215 |
| 11 | 2560 | 16640 | 2279 | 749 | 49 | 1117 | 506 | 4194 | 3583 |
| 12 | 1280[1] | 17920 | 2518 | 823 | 53 | 460 | 645 | 3854 | 4039 |
| 13 | 2560 | 20480 | 2858 | 936 | 60 | 355 | 250 | 4209 | 4104 |
| 14 | 2260[2] | 22740 | 3158 | 1036 | 67 | 53 | 92 | 4314 | 4353 |
| 15-65 | 2260[2] | 25000 | 3458 | 1135 | 74 | | | 4667 | 4667 |

[1] two - 640 acre farms with canning corn and peas

[2] fill in of irregularly shaped fields

[3] regional employment benefits

Table 16

DIRECT PLUS INDIRECT AND NET PRESENT VALUES

| Distribution System | Region | | Province | | Canada | |
|---|---|---|---|---|---|---|
| | B/C | NPV[1] | B/C | NPV[1] | B/C | NPV[1] |
| Closed Conduit | 1.15 | 11,190 | 1.25 | 18,547 | 1.54 | 40,629 |
| Canal | 1.65 | 31,056 | 1.80 | 38,413 | 2.26 | 60,495 |

[1] Thousands of dollars

*Table 17*

SENSITIVITY OF BENEFIT-COST RATIO TO CHANGES IN VARIABLES

| Variable | Benefit-Cost Ratio: Closed Conduit System | Benefit-Cost Ratio: Canal System |
|---|---|---|
| Base Case | 0.82 | 1.13 |
| Yields or Prices: | | |
| + 20% | 1.07 | 1.52 |
| - 20% | 0.58 | 0.76 |
| Livestock Benefits Excluded | 0.67 | 0.90 |
| Discount Rates (Base Case 6%): | | |
| 4% | 1.13 | 1.54 |
| 8% | 0.65 | 0.90 |
| Construction Costs: | | |
| + 25% | 0.71 | 0.97 |
| Cropping Patterns (Base Case: cereals-forage-specialities 40-40-20): | | |
| 40-50-10 | 0.68 | 0.92 |
| 40-30-30 | 0.80 | 1.10 |
| Development Rate (Base Case 14 years) | | |
| 7 years | 0.88 | 1.23 |
| 28 years | 0.69 | 0.94 |
| Energy Costs: | | |
| Fuel and Lube +190% | 0.77 | 1.05 |
| Pivot Electricity | | |
| + 50% | 0.82 | 1.11 |
| - 50% | 0.82 | 1.16 |

in the sensitivity analysis: 40-50-10 and 40-30-30. A decrease in oilseeds and specialties from 20 percent to ten percent of the crop mix resulted in a decline in the benefit-cost ratio of about 18 percent. A ten percent increase in specialty and oilseed crops had very little effect on the benefit-cost ratio. This analysis underscores the importance of producing high-value crops under irrigation.

### 6. *Development Rates*

In the base case it was assumed that the project would be developed over a 14-year period. If the development period was reduced to seven years the benefit-cost ratio would increase by eight percent; if it was extended by 14 years to 28 years, the benefit-cost ratio would be reduced by 16 percent. While it is not critical, it is in the developer's interest to increase the developed acreage as soon as is practically possible.

### 7. *Energy Costs*

Petroleum fuel prices could increase considerably faster than other crop costs over the economic life of the project. The sensitivity test increased on-farm fuel and lube costs by a forecasted 190 percent (in real terms) over the life of the project. This induced a seven percent reduction in the benefit-cost ratio which would tend to caution agricultural producers against shifting toward more energy-intensive production methods.

Pump electricity costs were increased by 50 percent over the base case; the benefit-cost ratios declined by only about two percent. These costs are a relatively small proportion of total production costs and hence do not significantly affect project feasibility.

### 8. *Summary of Sensitivity Analysis*

The sensitivity analysis indicated that the most significant factors in determining the economic feasibility of the project are crop yields, crop prices and discount rates. While variables appeared to be less significant, they could still be very important to the overall feasibility of the project, particularly when it is considered that the effects of errors in two or more assumptions can be multiplicative.

From the results of this study and experienced judgement, the direct benefit-cost ratio can be expected to fall within these ranges:

| | |
|---|---|
| Closed conduit system | 0.66 to 0.98 |
| Open canal system | 0.90 to 1.36 |

## F. Distribution of Benefits

The distribution of direct and secondary benefits among the three basic administrative jurisdictions affected by the project (the Blood Indian Reserve, the Province of Alberta, and Canada) was estimated based on the multipliers used in the derivation of secondary benefits and a distribution of direct benefits as follows:

1. The reserve would receive all direct crop and income stability benefits and 33 percent of wages paid to construction workers.
2. The province, exclusive of the reserve, would receive 67 percent of wages paid to construction workers, all direct benefits and 63 percent of secondary livestock benefits, and 57 percent of secondary crop benefits.
3. Canada, exclusive of the reserve and the province, would receive 43 percent of secondary crop benefits and 37 percent of secondary livestock benefits.

The resulting distribution to the three administrative jurisdictions was as follows:

| | |
|---|---|
| Blood Indian Reserve | 40% |
| Province | 40% |
| Canada | 20% |

Both the closed conduit distribution system and the canal system would produce a similar distribution of benefits.

The estimated distribution of benefits does not necessarily reflect the degree to which each jurisdiction should contribute to the cost of the project; it does not necesarily follow from the favorable economic analysis that the project would be *financially* feasible for any of the beneficiaries. Social considerations aside, the Blood Tribe, as the probable managing agency for the project, should carry out a comprehensive financial analysis of the project before any financial commitment is made toward implementation. The economic feasibility analysis has been conducted from a provincial perspective and must not be construed as a financial analysis. The economic feasibility recognizes the benefits of utilizing unemployed labor and considers that interest is a transfer of capital rather than a cost. Such is not the case in a financial analysis — labor and interest charges must be considered in the cash flow. Similarly, in the economic feasibility analysis a *real* discount rate was used to discount future benefits and costs to present values; in a financial analysis the market interest rates for capital must be used.

# CHAPTER VI: ENVIRONMENTAL EFFECTS

*The irrigation project will have little impact on the flora and fauna in the Big Lease.*

The environmental portion of the study involved two separate component studies. Firstly, the potential environmental effects of irrigation works and irrigation farming on the ecosystem were identified and described, and secondly, the potential effects of irrigation farming on the groundwater regime and on soil salinization within and adjacent to the proposed development were identified and evaluated. The former study was carried out by International Environmental Consultants Ltd. and is reported in detail in Supplement 5; the latter was carried out by Simco Groundwater Research Ltd. and is reported in Supplement 6.

## A. Effects of Irrigation Works

An inventory of the flora and fauna in the study area was based on reviews of existing information, on aerial photography and field surveys, and on discussions with people having relevant information. The field surveys involved vehicle and foot reconnaisance, a small mammal trapping program, and winter track counts.

In general, the study area is not a favorable wildlife habitat because of adverse topography and aridity, and because much of the land is under cultivation. The limited field survey yielded evidence of white-tailed jack rabbits, coyotes, red foxes, weasels, badgers, deer mice, Richardson's ground squirrels, meadow voles and shrews in the study area. Ungulates and furbearers are rare; sharp-tailed grouse are common, particularly along the route of Mokowan Ridge Canal.

### 1. *Mokowan Ridge Canal*

The loss of wildlife habitat, the impeded movement of animals, and the effects of improper use of herbicides to control weed growth in the canal are the usual negative impacts associated with irrigation canals. Loss of habitat will not be significant along the Mokowan Ridge Canal. The canal may affect the home range of some coyotes and the population of sharp-tailed grouse, and it may restrict the movement of deer across the reserve. However, these effects are judged to be minor.

It will be necessary to control submerged aquatic macrophytes in the canal. The herbicide usually used in southern Alberta is magnicide-H which is toxic to fish. Careful application of this herbicide should have little or no environmental impact since it is highly volatile and leaves no residue, however improper application could affect flora and fauna in the canal and Mokowan Reservoir.

To its credit, the canal would provide water useful to waterfowl and terrestrial wildlife, and with careful management, plant growth along the canal banks could provide wildlife habitat without impeding the flow of water.

### 2. *Mokowan Reservoir*

Mokowan Reservoir will inundate approximately 430 acres of unimproved pasture. Little clearing would be required due to a lack of trees and tall shrubs in the area. Providing that low shrubs and grasses are burned off prior to flooding, any deterioration of water quality due to vegetation in the reservoir area is expected to be negligible.

Flooding the area would result in no significant loss of wildlife habitat; in fact, the reservoir could have a positive impact. It would provide a permanent water source for terrestrial wildlife and a habitat for waterfowl. If adjacent grazing areas are managed properly, there is the potential for the production of upland nesting ducks such as teals, mallards, widgeons and shovelers.

The reservoir would have little impact on the aquatic fauna for the existing water courses. If the operating range of the reservoir is restricted, it would have a high potential for the development of fish species such as pike, rainbow trout and Rocky Mountain whitefish. However, extensive drawdown usually characteristic of irrigation reservoirs will create an unstable littoral zone, which would limit the potential for aquatic habitat and fishery enhancement. Without reasonably stable water levels, it is doubtful if shoreline vegetative communities will become established, hence, the capability to support waterfowl would also be somewhat limited.

### 3. *Drainage of Sloughs and Ponding Areas*

Drainage of sloughs and ponding areas and more intensive farming will destroy habitat now suitable for use by wildlife, as temporary water bodies are important to migrating waterfowl in the spring. The loss of this habitat would increase the limitations to waterfowl production in an area where limitations are already severe. If drainage is routed toward catchment ponds rather than the river, the effects would be ameliorated to some extent, particularly if permanent water bodies are created which could support waterfowl broods from the hatch to the fledging stage. Catchment ponds could be created in existing wet areas or along coulees through the construction of dams.

### 4. *Distribution System*

Two types of distribution systems are under consideration: a buried closed conduit system and a surface open canal system. A buried closed conduit would be preferable since, once in place, it would have no continuing impact on the ecosystem. Canals would result in the loss of habitat and would present a barrier to the movement of some wildlife. On the other hand, canals would provide a water source for wildlife, and a habitat for dabbling ducks.

The use of herbicides to control terrestrial weeds in lateral canals could result in water quality degradation. Cultural methods of controlling weeds in lateral canals would need to be seriously considered if a canal distribution system were selected.

## B. Effects of Irrigation Farming

Irrigation farming would involve using Big Lease lands more intensively than is currently the case with existing dryland farming. The existing sloughs, ponding areas, abandoned farmsteads, and fence lines currently lying idle would likely be put into production, and would result in some loss of wildlife habitat. Improper irrigation practices could result in surface runoff from the irrigated area, increasing the amounts of herbicides, pesticides and nutrients entering the St. Mary and Oldman rivers. If subsurface drainage were needed at some time in the future, additional salt loadings in the river system would result. An increase in the production of forage would lead to an increase in cattle populations, and consequently grazing pressure and feedlots both on and off the reserve, and a decline in the quality of terrestrial and aquatic environments. With proper management, none of the foregoing effects are judged to be critical to the ecosystem of the area.

An extensive drilling and monitoring program was

carried out to identify and evaluate the effects of irrigation farming on the groundwater regime and the potential for soil salinization. Soil salinization occurs when mineralized soil moisture at or near the ground surface continually evaporates and minerals precipitate. A key factor affecting the amount of evaporation is the depth of the water table below the ground surface. In general, evaporation is minimal when the water table depth exceeds 1.5 to 3.0 m. However, additional water applied to the surface through irrigation could cause the water table to rise.

The depth to bedrock has a strong influence on the location of the water table in the Big Lease. The bedrock surface in the western part of the study area is within 3 to 8 m of the ground surface. The depth to bedrock increases to more than 100 m toward the eastern part of the Big Lease. Water level measurements indicate that the depth to the water table is about two metres in the northern and western parts of the Big Lease and increases to more than 35 m in the central and eastern parts. The only groundwater discharge area is along the St. Mary River, and is highly mineralized.

Computer simulations of the groundwater regime indicate that a large area of the central and eastern part of the Big Lease appears to be irrigable without the possibility of a rise in the water table and accompanying soil salinity problems. This area corresponds approximately with the most suitable areas for irrigation identified in the land classification component. The St. Mary River Valley will remain the only groundwater discharge area. Along the western part of the Big Lease where the present water table is closer to the surface, there is a strong risk that irrigation could cause a rise in the water table sufficient to expand the existing saline soils. Consequently, irrigation should be avoided along the western margin of the Big Lease.

Under certain conditions in the soil horizon and with over-irrigation of crops, perched groundwater systems could develop at a level higher than the permanent water table, resulting in soil salinity problems. The potential for perched groundwater systems would require further analysis, but again the need for good management of the irrigation project is apparent.

# CHAPTER VII: SOCIAL IMPLICATIONS

*The Blood Tribe is dedicated to holding fast to their agricultural heritage, an integral part of members' lives. Irrigation farming and the secondary industries it would foster are in keeping with this tradition.*

The objectives of the social component were:

1. to inform tribal members of the feasibility study;
2. to obtain public input and feedback concerning the impact of the proposed project on the reserve population;
3. to determine social acceptability of the project to the tribe;
4. to determine the social benefits to tribe members if the project was implemented; and
5. to determine the social impact of physical works and irrigation farming on tribe members.

The study was conducted by P.M. Associates and was directed by representatives of the tribal administration. Supplement 7 gives a detailed account of the social component.

The consultant also was responsible for arranging for access to the reserve for all components and providing liaison between study personnel and members of the tribe and tribal government as required.

In carrying out the study, the consultant reviewed all studies related to the subject that had been carried out before. An information officer from the tribe was hired to keep tribal members informed of the progress of the study. Newsletters were prepared and mailed, and audiovisual materials were prepared and presented at workshops and meetings. A questionnaire was prepared and assistants from the tribe were hired to conduct interviews to determine the attitude of tribe members to the proposed project. The con-

sultant also participated in a special working group concerning training in conjunction with the implementation component.

Although the social component was concerned with the entire tribal population, some special groups were identified for particular attention. These included the Blood Tribal Council and the Blood Tribal Administration, those most likely to take advantage of the farming opportunities created by implementing the project, and individuals resident on land in areas where right-of-way would be required for works constructed to realize the project.

## A. Background

### 1. *Demographic Profile*

The reserve is home to 4,300 to 5,800 members of the Blood Indian Tribe. The population is very young —54.1 percent are under the age of 20. By 1999, the population of the under-20 age group is projected to increase to 4,600 members. By that time, the 20-64 age group will increase from 2,263 members to 4,500 members. The off-reserve population, now 20 percent of the tribal membership, will increase to comprise 30 percent of the tribal membership by 1999. These data point to a need for a substantial increase in education and employment opportunities on the reserve, presum-ably to be met by on-reserve development.

The present per capita income is low — only $3,234.00 per annum compared to the national average of $8,900.00 per annum. The fact that members are exempted from paying income tax and that the tribe provides housing must be considered in comparing these incomes. Within the tribe, incomes and standards of living vary principally according to the levels of education and employment in the family, whether the family resides in one of the reserve communities (Standoff, Moses Lake, Lavern) or in one of the homes scattered throughout the countryside on the reserve, and whether the family enjoys the benefit of holding reserve land.

### 2. *Government Services*

The reserve is governed by a chief and 12 tribal councillors. Elections are held every two years. The tribal council employs an administration which is responsible for an annual budget of over $12 million. The tribal government provides a variety of services to band members, primarily of a social or economic nature. These are:

a) Social Development

The Social Services Department is principally con-cerned with providing direct social assistance to a substantial percentage of the on-reserve population. The young, the elderly, and the mentally and physically infirm receive special protection and care. The programs are administered under contract with the Department of Indian Affairs, and the Province of Alberta is also involved.

b) Education

The Education Department is advisory in nature, as education services for tribe members are provided by either the Department of Indian Affairs (on-reserve schools) or by school authorities in the surrounding regions (a substantial proportion of the on-reserve school-age children attend off-reserve schools). The Eduction Department succeeded recently in reviving agricultural instruction with the construction of a new facility at St. Mary's School in the southern portion of the reserve. School drop-out rates, estimated at some 35 percent before students obtain grade 12 standing, remain a problem for the Education Department. Few Blood students are presently involved in post-secondary education.

c) Housing/Public Works

A shortage of housing is a very serious problem on the reserve. Out of the total number of 745 occupied houses, some 379 are in acceptable condition and 366 are in need of major repair. Eighty-one new houses are required. Currently, the housing program provides some 50 new units annually, however within 20 years, about 1600 family units will be needed. The shortage of new and acceptable housing will continue to be a problem in the future as the population on the reserve expands.

d) Land

The Land Department is concerned with administering the land resources of the tribe. Lands are either publicly held and controlled by the tribal council, or are held by individual tribe members. In the case of lands held by individuals the right to use of the land and the right to any income generated from working on the land accrues to the individual who is recognized as the rightful holder. The income from public lands provides a substantial proportion of the income of the tribal government. Some 74,500 acres of land on the reserve are controlled by the tribal council, while approximately 265,000 acres are held by individuals. About 200,000 acres are cultivated. Of the cultivated area, 170,000 acres are leased to non-reserve farmers. The revenue from leases generates $1 million annually for the tribal government and $5 to $6 million annually for individual tribe members.

e) Protection Services

The Protection Services Department is concerned with the provision of policing, fire and ambulance services on the reserve.

f) Health

This department works with the doctors and hospitals in the surrounding region to ensure that the health care provided meets the requirements of the tribe. It provides an on-reserve medical presence.

g) St. Paul's Treatment Centre

This alcohol treatment centre located on the reserve administers a 28-day rehabilitation program.

h) Recreation

The Recreation Department co-ordinates and enhances recreation opportunities for tribe members.

i) Economic Development

The activities of this department will be highlighted in the following sections on economics and agricultural activity.

### 3. *Employment on the Reserve*

The tribal government is the principal employer on the reserve, employing 831 of the 1670 person labor force in 1979. Of these employed people 2/3 were permanent staff and 1/3 were employed seasonally. About 30 percent of the available jobs were located off the reserve. The study estimates that the creation of some 1,500 new jobs — 75 per year — will be required during the period from 1979 to 1999.

### 4. *Economic Profile*

The income of the reserve and its residents is derived from employment activities, transfer payments from the federal and provincial governments, land leases, agricultural revenue, and other investments.

Government transfer payments in the form of direct payments and program funding are the largest source of income to individuals on the reserve, followed by agriculture revenues and employment income. Although individual incomes from these sources total $15 million annually, the reserve receives very few secondary benefits from this income. Most purchases are made in the communities surrounding the reserve, as there are few outlets on the reserve where money can be spent. The few outlets that there are account for only about seven percent of the total income of the reserve. The multiplier effects of earned income circulating through the reserve's economy are minimal, and the study estimates that some 50 man-years of employment are lost by the off-reserve expenditure of on-reserve income.

The natural resources of the reserve provide some external income to the tribe but, apart from agricultural land, they are not likely to provide a major economic impetus in the near future. Royalty revenues from oil and gas resources on the reserve exceed $3.5 million annually at the present time, however, such activity does little in creating direct job opportunities. There are deposits of sand and gravel in numerous locations on the reserve but these deposits are of low quality and buried too deep to be used economically. Fossilized oystershell beds located on the reserve do not warrant commercial production. Two seams of coal have been discovered within the reserve: the shallow St. Mary seam has outcrops in some areas, and the Galt seam lies at a depth of approximately 200 metres in the Big Lease area. Preliminary indications are that development of this resource by surface mining is not feasible, but that subsurface mining (in locations other than the Big Lease) may some day be feasible. The major resource available for immediate development is the vast quantity of agricultural land.

### 5. *Agricultural Activity on the Reserve*

The Blood Tribe has always been interested in agriculture. However, on-reserve technical development has lagged, there have been difficulties in mobilizing capital, the increasing population has created pressures and training and education of farmers has been needed but has gone unfulfilled. As a result the full potential of agricultural opportunity on the reserve has not been realized. As well, the attitudes of some tribe members have further complicated the situation. The tribal council has consistently emphasized agricultural development as a priority of the tribe by:

a) encouraging the formation of a 1974 pilot irrigation project comprising 18 family farm units using irrigation;

b) initiating a substantial dryland farm, working some 6,700 acres in the southeast portion of the reserve;

c) developing an intensive irrigation farming operation of 1,550 acres and a dryland farming operation of 1,420 acres near the northern part of the reserve;

d) operating a band ranch with 770 head of cattle; and

e) starting up a new feedlot to accomodate 1,200 head in the north end of the reserve.

Most of the agricultural activities have been associated with the Economic Development Department. The operations are profit-oriented and require sophisticated management. The operations have been successful in terms of earnings, employment and training. A corporate approach has resulted in

strong production, marketing, financial and employee management.

Some of the negative experiences of the tribe in agricultural development have pointed to the need for strong financial management, substantial investments in long-term training and advisory services for Indian farmers, timely and responsive project funding, sufficient capital so that operations may be adjusted to markets as they change, and a central organization to administer the project. The 1974 pilot irrigation project was not completely successful, mainly because of a lack of some of the factors described above.

The Blood Tribe prepared a master economic plan in 1979 (Blood Tribe Economic Development Department; 1978). The plan gives highest priority to Indian farming and ranching of the tribe's agricultural land. The master plan proposes policies to shield and protect land use in the future, and already the plan is producing positive results through employment creation, development of secondary industry, accessing of outside financial resources, and improving educational and training opportunities on the reserve.

## B. Social Acceptability of the Project

In considering the social acceptability of the project, the study proposed an implementation plan for the project based on the findings in the implementation component. First, an enabling agreement would be negotiated, followed by a construction period lasting three to five years. The construction operations would be managed by an overseeing committee, possibly an extension of the existing tripartite committee. A corporate farming entity would be established which, on completion of construction, would be responsible for on-farm development and the administration of water rights, and would bring on stream about 2,500 acres of farm land per year over ten years. Family farming on a substantial amount of the developed acreage would eventually be promoted, with specialized entities operating some blocks.

The study looked at what changes would be required on the part of tribe members who would construct, operate and farm the project, and examined whether members could make the transition from carrying out their present day activities to being involved in irrigation farming as trainees, workers and managers.

If the successful applicants were drawn from those presently unemployed, substantial adjustments in lifestyle would be required, and training would be required to assist in the successful transition to employment. However, the past experiences of the Economic Development Department would point to likely success; heavy equipment operation and construction training activities and enterprises have been relatively successful. The effects of the training would be enhanced because real opportunities for on-reserve employment would await those who graduated.

In order to take full advantage of the opportunities created by this project, tribe members would be required to fill the roles of trainees and employees in heavy equipment operation, in irrigation farm land development and operation, and in the management and operation of the project and its related infrastructure. The study presumes that younger tribe members with a strong aptitude for farming, or those experienced in farming but who are without reserve land and/or capital for equipment would be the strongest candidates for the employment opportunities. The results of a survey conducted by the consultant for the implementation component strongly support these assumptions. The survey found a high level of interest in agricultural pursuits among tribe members, and their experience with agricultural employment led all other categories of employment and work experience in the survey data.

Successful applicants for management roles would probably have existing management experience with tribal enterprises or other endeavors. A growing group of Indian managers on the reserve who have developed since the beginnings of tribal self-government in 1967 would form at least part of the management group required to implement this project. Further specialized management training would be required for such people. Their training would possibly include acting as assistant managers or attending educational institutions either on a short term or long term basis.

A training scheme required to prepare applicants for future employment requires:

1) determining the skill profiles for all jobs created by the project;
2) determining the inventory of skills held by band members and identifying their willingness to undergo training;
3) comprehensive classroom and on-the-job programs to close any skills gap thus identified;
4) organizing existing training resources to meet the specific requirements; and
5) setting time lines for the training process that use work situational training on the project to the maximum and which deliver graduates close to the time at which they will be required.

The facilities of St. Mary's School are an obvious choice for classroom training. On-the-job training

can be provided either at the project or at existing tribe agricultural operations. If the latter is chosen, direct funding should be provided so that those organizations do not suffer a training cost detracting from their profitability.

A training course for road construction previously discussed has already started and will be continued. The experience and training gained in that setting is directly applicable to the heavy construction opportunities of this project.

The project is consistent with the regional economy; existing tribe agricultural projects and farms now being operated by individuals demonstrate that such employment is in tune with the way of life of the Blood Tribe, provided that the necessary support programs and assistance are available. Specifically, the farms must have a strong training and advisory resource available to them over the long term. The project must be well-capitalized and strongly managed from a central organization.

## C. Social Benefits

A substantial increase in the employment of tribe members, both in the construction and operation of the project, is the principal social benefit accruing from the project. For example, estimates of the employment which would be created if the project were constructed as a canal system are as follows:

1) Construction Phase

Construction would create 567 man-years of employment with 116 full-time positions at its peak. The wages paid would total $10 million over the construction period of the project.

2) Farming Operations

Farming would create about 50 man-years of employment annually (about 20 full-time positions). The wages would total $865,000 each year for the life of the project.

3) Operation, Maintenance and Management

The operation, maintenance and management of the project would create 9 man-years of employment annually. The wages would total $115,000 each year for the life of the project.

The total employment which would be created during the first 15 years of the project would be 940 man-years, involving a total wage payment of $16.2 million. If the secondary opportunities resulting from the project were exploited, another 6 full-time and 6 seasonal positions would be created. All of the above positions could be filled by members of the tribe.

The economics component concluded that the net crop returns to management, capital investment, land and water attributable to converting from dryland farming to irrigation farming on the Big Lease would total $3 million to $4 million (1981 dollars) annually, depending upon the crop types grown.

Economic stimulation on this scale could give rise to a new initiative on the Blood Reserve. The Indian farmers and project operators would themselves become self-sufficient, as new role models for their fellow tribe members, and would possibly stimulate existing land-holders to begin developing their own resources. There would be an immediate and substantial reduction in the costs of providing social assistance and in the cost of dealing with other negative spinoffs from that depressed state of existence. The Blood Tribe would realize ongoing benefits and increased development from its renewable resource in a manner consistent with their traditional lifestyle and with their desire to remain productive in their own communities. The resulting increase in self-esteem and the development of a sense of accomplishment among the tribe members associated with the project could provide an impetus to the increased pace of development and economic activity on the reserve.

## D. Social Impact

Although the construction of physical works associated with the project will have an impact on land-holders, open water conveyance systems exist on the reserve and in the surrounding region, and acceptance of such systems is high. The problems of land severance were recognized by the 18 people directly affected by the canal, but they raised no serious objections to the system in light of the overall benefit that would accrue to the tribe from the project. Of course, their acceptance is predicated on receiving adequate compensation for loss of land.

The impact of the reservoir does not seem to be substantial either as a source of danger or opportunity; it is not located near any settlement, nor does it present a recreational opportunity for tribe members because of variable water levels.

The implementation of the project would affect government services of the reserve as well. A summary of the effects of the employment and income generated by the proposed project on those services is as follows:

1) Social Development

The project would result in a reduction of welfare costs and case loads, daycare requirements, and alcoholism and the associated social problems.

2) Education

A training program would be required to

provide up to 150 construction positions, 50 farm workers, and 10 operations, management and maintenance positions. The number of trainees accepted in training programs should allow for drop-outs and eventual employment in other areas not associated with the proposed project. Training would also be required to prepare for secondary employment opportunities.

The training requirement would represent about 2,800 man-months of classroom instruction.

3) Public Works

The Department of Public Works would be required to maintain roads in the irrigation project area. Additional manpower and equipment would be required to facilitate this. This department would possibly administer contracts to construct capital facilities and create housing for employees as well.

4) Land

The Land Department could be involved with the acquisition of right-of-way for proposed conveyance works with appropriate compensation.

Lease revenue now exacted from the Big Lease area is required by the tribal administration to maintain essential government services, at least the present level of revenues (escalated by inflation) must be provided to the tribal administration to maintain these services. This could probably be accomplished by agreement between the Land Department and the management entity for the proposed project.

5) Economic Development

The implementation of the overall agreement and efforts to exploit secondary benefits would be co-ordinated through the Economic Development Department.

## E. Summary

The social component concluded that the proposed irrigation project presents a welcome opportunity for the Blood Tribe. In recent years unemployment on the reserve has been in the range of 50 percent. This situation could become worse with the projected increases in the size of the labor force. Development of the project would create 872 man-years of on-reserve employment for tribe members in the first 15 years, and would provide direct wages of about $15 million. Additional employment and economic benefits would be created through secondary industries. The tribe would have an increased sense of accomplishment and a reduced dependence on external funding sources.

Agriculture is a part of the cultural tradition of the tribe and is in tune with their attitudes toward utilizing their sacred land resources in perpetuity for the benefit of the tribe. The project would provide the opportunity for tribe members to remain on the reserve without undergoing the attendant cultural disruptions resulting from off-reserve migration.

Training programs would be essential to enable tribal members to take advantage of job opportunities. In general, the tribal membership is strongly committed towards vocational training and upgrading. The success of existing tribal agricultural projects indicates that the transition from their present lifestyle to agricultural pursuits can be successful, providing well-thought-out training programs and advisory services are available.

The sources of a water supply and types of conveyance systems are not considered to be critical issues on the reserve. The project would have both positive and negative effects on the delivery of services by the tribal government. Additional resources may be required in areas such as finance, public works, housing and education. There would be a considerable reduction in the costs of social and preventative programs. The long-term effects are clearly preferable to a continuation of the existing situation.

# CHAPTER VIII: IMPLEMENTATION

*Whether the open canal system or closed pressure conduit system is chosen, construction of the irrigation project will create jobs for tribal members.*

The implementation component study was carried out under the assumption that the results obtained in the other components of the study would lead to the conclusion that the development of irrigation agriculture on approximately 25,000 acres of land in the Big Lease area would be feasible.

The component examined possible organizational arrangements and sources of financial and technical assistance. It addressed the factors affecting the rate of conversion of dryland to irrigation, and outlined a system to meet the training requirements of the project.

The study was carried out by Pratt Consulting Inc. under the direction of an implementation subcommittee of the tripartite committee. A detailed account of this study is provided in Supplement 8.

## A. Proposed Organizational Structure

Implementing the project would require substantial financial and technical assistance from various agencies of both the federal and provincial governments as well as from the tribe. To obtain the commitments required, some form of financial agreement would be required between the federal government, provincial government and an agricultural corporation established by the tribe. It would be necessary for the three parties involved to be satisfied with the ways in which the agreement was administered and in which the technical assistance was co-ordinated and delivered.

The study concluded that the Alberta Irrigation Act could not be applied to the Blood Indian Irrigation Project without substantive legislative changes

to both the Irrigation Act and the Federal Indian Act. Without such changes, it would be necesary to provide an organizational structure that would fulfill the management roles required of an Irrigation District and of the Alberta Irrigation Council with respect to the project.

As an overall aim, such an organizational structure must be designed to ensure competent management at all levels, to provide adequate incentives to managers and laborers, and to maximize return on the capital investment for the benefit of participants in the project and the tribal population in general.

The essential elements of the organizational structure are illustrated in Figure 17. The elements are a Tripartite Board, a Blood Indian Irrigation Agricultural Corporation, Construction Managers, Farm Operation Units, an Agricultural Trining Organization, an Agricultural Exten-sion Service, a Farm Related Secondary Enterprise Group and a Water Control Group. The composition and functions of these key elements would be as follows:

### 1. *Federal-Provincial-Tribal Tripartite Board*

This board would be established under the terms of the proposed federal-provincial-tribal corporation agreement and be composed of members appointed by the three bodies. It would act as the management committee for the agreement and would fulfill the role of the Alberta Irrigation Council with respect to the project. It would select and provide general supervision for the construction managers and provide general supervision in at least the start-up and initial years of operation of the project. The board would remain in existence for at least the term of the agreement, and would continue in an advisory role thereafter if required.

### 2. *Blood Indian Irrigation Agricultural Corporation*

A tribe-owned corporation would be formed, with the board of directors appointed by the Blood Tribal Council. The Council should appoint, at least initially, an experienced irrigation farmer and a member from the agri-business community to the board. This corporation would act as the project implementation agency of the tribal council and would carry out duties similar to those of an irrigation district, as prescribed in the Alberta Irrigation Act. The corporation would be responsible for the start-up of the first farm units, and would subsequently arrange and administer agreements with the farm operation units for all or most of the farm units in the project.

The corporation would be responsible for developing farm-related business enterprises, and for negotiating and managing joint-venture agreements, as the opportunities arose, for the production and processing of specialty crops.

### 3. *Construction Management*

The construction of the project would be managed by an agency which would have as part of its mandate the maximization of employment and use of tribal members and resources as the works were built.

### 4. *Farm Operation Units*

Although the long term aim of the tribe may be the establishment of individual farms, the formation of farm operating groups would be required initially to bring the farm units on line as they were converted from dryland to irrigated agriculture.

These groups or units would be composed of self-selected groups of people who had successfully completed prescribed training courses and on-farm experience requirements, either with the corporation in the start-up phase or otherwise, who could work co-operatively under supervision and who had applied to the corporation for the right to operate a block of irrigated land. These groups could be made up of families or extended families or could be composed of persons who had developed a good working relationship during the training period. They would show potential for developing into competent farm workers and managers, and would thus provide a nucleus of expertise for ongoing operations. Various types of business organizations for these units would be possible (e.g. subsidiary corporation of the Blood Indian Irrigation Agricultural Corporation, independent corporation, co-operative, partnership, or an association of operators).

Farm operation units would be responsible for operating a block of irrigated land, under either a grain-forage crop rotation, in a manner that would provide an adequate return for the labor, land and water used.

### 5. *Agricultural Training Program*

Since the project is intended primarily to benefit tribal members who are not now land holders and who wish to farm but require training in irrigated agriculture technology, provision for a training organization must be made. Both academic and hands-on training must make up the program.

The overall objective of the training program would be to provide a stream of trained construction workers, farm managers and farm workers for the

## PROPOSED ORGANIZATIONAL STRUCTURE

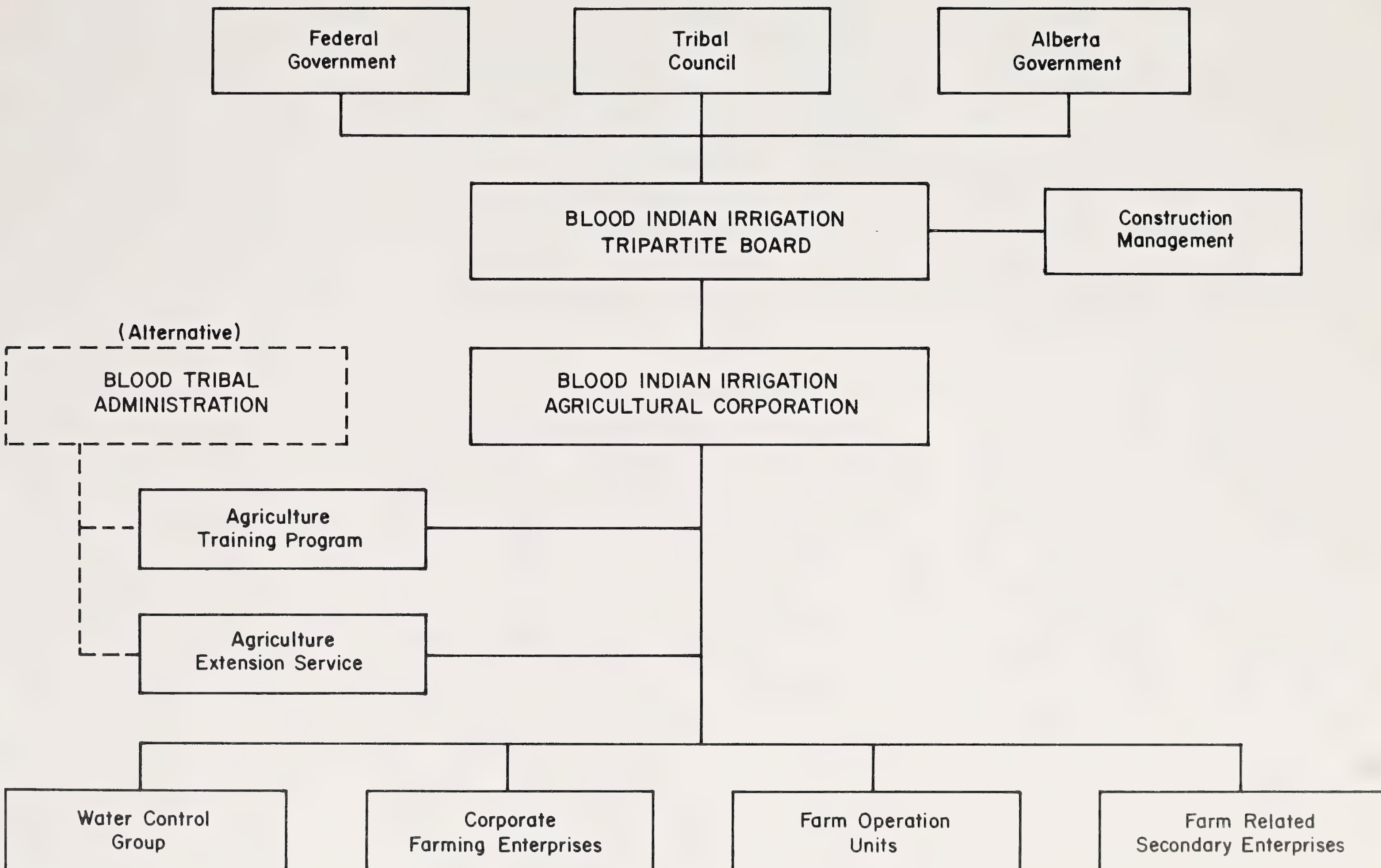



FIGURE 17

initial staffing and for the ongoing needs of the project.

The agricultural training program would be administered by the corporation or the education department of the tribal administration. The program would provide agricultural and construction training to tribal members interested in participation in the project. The program would ensure the corporation's training needs were met with the help of such agencies as St. Mary's School, the Lethbridge Community College, Alberta Agriculture — Extension and Irrigation Divisions, Alberta Advanced Education and Manpower and Canada Employment and Immigration Commission. Various other training institutions could assist in the financing and delivery of academic portions of the training and could offer on-the-job training opportunities with companies and agencies both on and off the reserve.

### 6. *Agricultural Extension Services*

In addition to the organization required to construct and bring the project into operation, ongoing agricultural extension services should be provided and secondary opportunities in farm-related enterprises should be developed.

The extension service would facilitate the supply of up-to-date agricultural information to the Blood Indian Irrigation Agricultural Corporation and the farm operation units. It could be administered by the corporation or, alternatively, by the tribal administration. This branch could provide service to all Indian farmers on the reserve, or just to the operators associated with the project. The concept would be to employ one or more fully-trained people to provide day-to-day assistance to the irrigated farm operators and facilitate their access to the services provided by other agencies such as Alberta Agriculture, Canada Agriculture, and the Alberta Indian Agricultural Development Corporation.

## B. Implementation Strategy

The timetable for implementing the study would be dictated by several practical considerations such as time requirements to negotiate a satisfactory tripartite agreement; physical construction limitations; availability of construction equipment; availability of trained construction workers, farm workers and farm managers; financial constraints related to phasing out revenues from existing dryland leases; and market development for irrigated agricultural products. Considering these factors, a total development time of 14 years is suggested. The proposed tripartite agreement could possibly have some flexibility to allow accelerated development if conditions warranted.

Assuming that, following the review of this report, the tribal council decides to pursue irrigation development on the Big Lease, the following is presented as a possible scenario for implementation. The implementation process could involve four phases; a "Considerations Phase", a "Negotiations Phase", a "Construction Phase", and an "Operations and Expansion Phase".

### 1. *The Considerations Phase*

The considerations phase would begin upon release of this report and would provide a three-month period for review of the report by the federal and provincial governments. During this time the tribal council could review the report, undertake a financial analysis and, depending on the outcome, prepare an initial presentation.

### 2. *The Negotiations Phase*

The negotiations phase could commence with presentation of a proposal by the tribal council to the provincial ministers of Environment, Agriculture, Native Affairs, and Federal and Intergovernmental Affairs and the federal ministers of Indian Affairs and Northern Development and Agriculture. The formation of a negotiating committee having representation from the provincial and federal governments and the tribal council would likely result from such a presentation. Initially, such a committee would work either to formulate an agreement in principle to proceed with the project, or to terminate the project. If an agreement to proceed was established, more detailed studies of certain aspects of the project as discussed in this report (or subsequently determined to be required by the parties) could be carried out. This phase would conclude with the incorporation of the agricultural corporation, the completion of the design of the training program, and the signing of a final agreement. It is expected that this phase would last about 15 months following the considerations phase.

### 3. *The Construction Phase*

Commencing with the signing of the enabling agreement, the construction phase would involve three years to complete the Mokowan Ridge Canal and Mokowan Reservoir, and two years to construct the distribution system and its first laterals. The work on the distribution system and the first laterals could be carried out at the same time, which would reduce the overall time required by about two years.

### 4. *The Operations and Expansion Phase*

During the operations and expansion phase, the

installation of on-farm irrigation equipment, organization of farming units and capital equipment, preparation of land and developmental cultivation and operation would take place on about 2,500 incremental acres each year until 25,000 acres had been reached. The process would be concluded in ten years from the completion of the contruction phase. The overall time requirement could be reduced by accelerating the development of the irrigable area.

## C. Financial Requirements

Substantial costs will be incurred in implementing the project. The capital costs for constructing the irrigation headworks, the Mokowan Ridge Canal, the Mokowan Reservoir and the distribution system were estimated by PFRA at $52,000,000 for the gravity system and $96,000,000 for the pressure conduit system. The additional capital costs for the on-farm irrigation equipment, farm machinery and buildings could vary considerably, depending upon the crops grown, the size of the farm units chosen, and the nature of the equipment purchased. However, an estimate of $2,000,000 per 2,500 acre block of irrigated land, or $800 per acre, based on information supplied by the economics component was used for planning purposes. Thus, the total capital costs would be in the order of $72,000,000 if the gravity system was installed, and $116,000,000 if the pressure conduit system was selected.

The grant or lending practices of possible funding sources were investigated as they applied to developments on Indian lands. Details can be obtained from Section 6.2 of Supplement 8.

The most likely agencies to be involved in funding for the water conveyance and distribution systems are Canada Indian Affairs and Northern Development, Alberta Environment through its water resources and specifically irrigation headworks mandate, Alberta Agriculture through its program of grants for irrigation distribution system rehabilitation and expansion, and the Blood Indian Tribal Council through its economic development program.

The most likely agencies to be involved in funding for the on-farm capital requirements are Canada Farm Credit Corporation, Alberta Agricultural Development Corporation, private lending institutions, the Blood Tribe and Alberta Indian Agricultural Development Corporation.

In addition to capital costs of the project, funding will be required for the training program. Technical and/or financial aid could be available from Alberta Agriculture, Alberta Advanced Education and Manpower, Canada Employment and Immigration Commission, and Canada Agriculture.

Private lending institutions could provide operating capital for crop requirements, and could be obtained by the proposed Blood Indian Irrigation Agricultural Corporation and the farm operating units.

### CONVEYANCE SYSTEM CAPITAL FINANCING

Three possible financial packages for providing the required project and on-farm capital equipment funding were formulated, under the assumption that the gravity distribution system would be selected for implementation. These packages, together with the assumptions upon which each was based, are presented for illustrative purposes only. The actual arrangements would need to be settled in negotiations between the two levels of government and the tribal council.

The financial packages formulated here are summarized in Table 18.

*Package No. 1*

This package assumes that the Alberta Government would designate the turnout on the Belly-St. Mary Diversion Canal, the Mokowan Ridge Canal and the Mokowan Reservoir as headworks and would construct, own and operate these facilities. The Government of Canada would provide the distribution system beyond the Mokowan Reservoir and one-half of the on-farm capital required. The Blood Tribe would provide the remaining one-half of the on-farm capital required.

*Package No. 2*

This package assumes that the Alberta Government (through Alberta Environment) would construct, own, operate and maintain the headworks as described in Package No. 1 and that the Alberta Government (through Alberta Agriculture) would provide 86 percent of the funds for the expansion of the distribution system similar to the assistance it currently provides to irrigation districts. The Government of Canada would finance the header canal, Phase 1 of the distribution system, the roads, 14 percent of the expansion of the distribution system, and one-half of the on-farm capital costs. The Blood Tribe would finance the remainder of the on-farm capital costs.

*Package No. 3*

This package assumes that the Alberta Government (through Alberta Environment) would construct, own and operate only the turnout facilities on the Belly-St. Mary Diversion Canal and designate these as the "headworks" but the full distribution system from the turnout to the farm gates would be eligible for 86 percent funding through Alberta

*Table 18*

POSSIBLE PROJECT FINANCING PACKAGES (IN $ MILLIONS)

| Package No. 1 | Alberta | Canada | Band |
|---|---|---|---|
| Headworks, including canal and reservoir | 20 | — | — |
| Distribution system | — | 30 | — |
| On-farm capital | — | 10 | 10 |
| Totals | 20 | 40 | 10 |
| Percentages | 29 | 57 | 14 |
| Package No. 2 | | | |
| Headworks, including canal and reservoir | 20 | — | — |
| Distribution system | | | |
| Header canal, phase 1 Laterals and roads | — | 18 | — |
| Phase 2 laterals and drainage | 10 | 2 | — |
| On-farm capital | — | 10 | 10 |
| Totals | 30 | 30 | 10 |
| Percentages | 43 | 43 | 14 |
| Package No. 3 | | | |
| Headworks (only turnout) | 1 | — | — |
| Distribution system — (including highline canal and reservoir) | 40 | 7 | — |
| Roads | — | 2 | — |
| On-farm capital | — | 10 | 10 |
| Totals | 41 | 19 | 10 |
| Percentages | 59 | 27 | 14 |

Agriculture. The Government of Canada would finance the other 14 percent of the distribution system, the roads, and one-half of the on-farm capital costs. The Blood Tribe would contribute the remaining on-farm capital costs.

The projected cash flow under Package No. 2 and a 14-year development schedule is outlined in Table 19.

## D. Training Requirements and Sources

In view of the present lack of experienced irrigation farmers among the non-land holder population on the reserve, an intensive training program will be required to provide a continuing supply of capable farm managers and laborers as well as a supply of trained construction workers so that maximum benefits can accrue to the Blood Tribe from both the construction and operation phases of the project.

A working group on training formulated elements of a long-range training program for irrigation agriculture on the reserve. Members of the group included representatives from the implementation study component, the Blood Tribal Administration, Alberta Agriculture, Canada Employment and Immigration Commission, and Alberta Advanced Education and Manpower.

The group recommended that the training program be integrated into a broader program of vocational training so that tribal members might take advantage of employment opportunities in other economic activities planned for the reserve. The group indentified a number of elements of a training program which should be further explored by the entity responsible for training the workers and managers for the project. These elements included:

1) The possibility of forming a "Blood Band Agricultural Training Institute" using the St. Mary's School facilities and land as a base.
2) The possibility of an affiliation of the proposed institute with the agricultural division of the Lethbridge Community College.
3) The possible application of the Alberta Agriculture Green Certificate Program to trainees in the proposed institute.
4) The possible application of Canada Employment and Immigration Commission funding programs to elements of the training program.
5) The possible use of Alberta Advanced Education facilities and services toward planning and implementing a vocational training program for the Blood Indians.
6) The possibility of pre-building roadways and land drainage systems, required for the project, to provide on-the-job training in surveying and other construction techniques.
7) The possibility of the Blood Tribal Administration working directly with construction companies engaged in the Alberta Environment program of irrigation rehabilitation and expansion to explore opportunities for training on these projects.
8) The possibility of obtaining on-the-job agricultural training at the Canada Agricultural Research Station in Lethbridge.

## E. General Observations

In order for the project to be given serious consideration by the governments of Alberta and Canada, it will be necessary for the Blood Tribal Council to fully endorse the project and take early actions that demonstrate this support.

Early action is needed in:

1) Adopting tribal administration and business practices that will inspire confidence in government agencies that the tribal council is development and business oriented and could handle a major irrigation project and the potential related opportunities.
2) Planning and implementing a broad vocational training program that would prepare tribe members for greater participation in existing and future agricultural activity on the reserve and a wide variety of other occupations now existing or likely to develop.
3) Adopting land administration practices that would work toward efficient land use on the reserve generally, and accomodate effective administration of the lands in the Big Lease area, should the project be implemented.

*Table 19*

CASH FLOW UNDER PACKAGE NO. 2
(IN $ THOUSANDS)

| | Alberta | Canada | Band |
|---|---|---|---|
| Year 1 | 2,812 | 328 | — |
| Year 2 | 10,172 | 328 | — |
| Year 3 | 8,172 | 328 | — |
| Year 4 | 129 | 9,261 | 1,000 |
| Year 5 | — | 4,000 | 1,000 |
| Year 6 | — | 3,800 | 1,000 |
| Year 7 | — | 2,900 | 1,000 |
| Year 8 | 860 | 2,066 | 1,000 |
| Year 9 | 860 | 2,441 | 1,000 |
| Year 10 | 1,978 | 1,622 | 1,000 |
| Year 11 | 1,720 | 1,477 | 1,000 |
| Year 12 | 2,411 | 1,392 | 1,000 |
| Year 13 | 433 | 1,653 | 1,000 |
| Year 14 | 344 | 56 | — |
| Totals | 29,891 | 31,652 | 10,000 |

# CHAPTER IX: SUMMARY OF FINDINGS AND RECOMMENDATIONS

*Tell-tale circles mark the fertile fields under the centre-pivot irrigation system.*

The overall objective of this study was to determine the feasibility of developing irrigation on the northeastern portion of the Blood Indian Reserve, commonly referred to as the Big Lease, considering technical, economic, environmental, social and administrative factors. The following summarizes the findings of the study.

## A. Technical Considerations

1. In general, the *topography* of the Big Lease is suitable for sprinkler irrigation but not suitable for gravity flood irrigation.
2. There are about 25,000 acres of *land* in the Big Lease *suitable for sustained irrigation*. However, for practical reasons, irrigating some of the privately claimed land outside the Big Lease would probably be necessary to realize the target area of 25,000 acres of irrigation.
3. Surface *drainage* of sloughs and ponding areas should be carried out in the early stages of development to increase productivity and facilitate the movement of irrigation equipment.
4. In general, the *climate* of the study area is suitable for irrigation agriculture. Occasional spring and fall frosts that could damage crops and frequent high winds, typical of southern Alberta, which affect the efficiency of sprinkler irrigation, may impose some limitations.
5. With irrigation, *yields* of dryland crops such as wheat, barley and canola would more than dou-

ble. Irrigation will permit production of specialty crops that cannot be grown under dryland conditions.

6. A representative irrigation *crop mix* on the Big Lease would be 40 percent alfalfa, 40 percent cereals, 15 percent oilseeds and 5 percent specialty crops. Typical specialty crops would be sweet corn, green peas and dry beans.
7. Peak *water requirements* for the representative crop mix would reach 7.7 mm per day, which could create a total water requirement of 9.4 $m^3/s$. Recognizing that not all sprinklers would be operating at the same time, even during peak demand periods, the water delivery system was designed for 7.9 $m^3/s$ for this feasibility study. This design flow would require further examination in the next study stage of this project.
8. Center pivots and end guns or corner systems for unimpeded quarter section blocks, and wheel roll systems for irregular shaped fields are the appropriate *sprinker systems* for the Big Lease.
9. Careful *management* of the irrigation system would be essential to minimize on-farm costs and maintain high yields. Most of the soils on the Big Lease have slow infiltration rates and hydraulic conductivities. Careful scheduling and control of water application would be necessary to minimize increases in the water table and soil salinity problems.
10. *Phasing development* of the irrigable land over a period of about ten years would provide for the gradual development of on-reserve agronomic expertise, development of markets and the phase-out of dryland leases and revenues therefrom. New development each year would average about 2500 acres. Each new irrigation block could be treated as a semi-independent management unit in terms of crop types, rotations, equipment and labor requirements.
11. A preliminary *water supply* study indicated that there would be sufficient residual flow (natural flow minus upstream uses) in the Waterton and Belly rivers to supply water to the Big Lease from the Belly-St. Mary Diversion Canal.
12. *Conveyance routes* from the Belly-St. Mary Diversion Canal would involve the use of either the Mokowan Ridge Canal and Mokowan Reservoir or Prairie Blood Coulee and a reservoir on the coulee. Cost estimates for each route were comparable. The Mokowan Ridge Canal route has greater flexibility in that it is a higher elevation and would permit water to be delivered to the Big Lease in a closed conduit under pressure thereby eliminating most of the pumping costs for sprinkler irrigation. The study focused on the Mokowan Ridge Canal route; however, the design provided for a diversion from Mokowan Ridge Canal to Prairie Blood Coulee for stock watering and small scale irrigation south of the coulee.
13. *Mokowan Ridge Canal* would be an unlined earth canal about 16.6 km long with a 5.0 m bottom width. The right-of-way for the canal would be 50 m wide and would require 215 acres of land of which 91 acres are cultivated. The cost would be about $5,500,000 (1981 dollars).
14. *Mokowan Reservoir* would store 16,900 $dam^3$ of water and flood about 454 acres of unimproved grazing land. The cost of the works would be about $14,000,000.
15. Two types of *distribution systems* were considered: a closed conduit pressure system and a canal system. The pressure conduit system would provide a positive pressure at each farm gate and would require booster pumps at only about 30 percent of the sprinklers. The canal distribution system would require pumps at all sprinklers. Surface drainage and a network of access roads would be required for both systems.
16. *The pressure conduit distribution system* would involve a 3.3 km canal from Mokowan Reservoir to a screening plant, a 1950 mm diameter header conduit delivering water to three laterals, and a 1650 mm diameter header conduit delivering water to four additional laterals. Thirty-seven acres would be required for the right-of-way, of which about nine acres are cultivated. The buried pipe would have minimal land disturbance beyond the construction period. The pressure conduit system would cost about $76,500,000.
17. *The canal distribution system* would have a 14.8 km main canal which would deliver water to seven lateral canals. Membrane liners would be required along some laterals to control seepage. Fifty-four acres for the right-of-way west of the Big Lease would be required, of which 14 are cultivated. Within the Big Lease the canals would require 550 acres. The canal distribution system would cost about $32,300,000.
18. A *summary of costs* of the two water delivery systems is as follows:

| Pressure Conduit Distribution System | |
|---|---|
| Mokowan Ridge Canal | $ 5,500,000 |
| Mokowan Reservoir | 14,000,000 |
| Distribution conduits and pumps | 76,500,000 |
| Total | 96,000,000 |

| Canal Distribution System | |
|---|---|
| Mokowan Ridge Canal | $ 5,500,000 |
| Mokowan Reservoir | 14,200,000 |
| Canal distribution and pumps | 32,300,000 |
| Total | 52,000,000 |

While these costs are sufficiently accurate to establish the feasibility of the project, they should be treated as preliminary and subject to revision pending more detailed study of design flows, the distribution system layout and design, and geotechnical factors.

## B. Economic Considerations

1. *The net crop returns* to labor, management, land and water (total crop returns minus on-farm costs) would vary from about $127 per acre to about $207 per acre depending on farm size and crop mix.
2. The net value added to crop production attributable to converting from dryland farming to irrigation farming would vary from about $107 per acre to $187 per acre depending on farm size and crop mix.
3. The net value added to *livestock production* would be about 33 percent of the net value added to crop production.
4. The increase in *stability of income* from irrigation farming as opposed to dryland farming is estimated to have a value of $2.94 per acre.
5. *Regional construction benefits* over the 14-year construction period (four years for the conveyance system and ten years for the distribution system) are estimated to add a net value to the regional economy of $22,100,000 for the pressure conduit distribution system and of $11,900,000 for the canal distribution system.
6. The *benefit-cost ratios considering only direct benefits and costs* of the project are estimated to be 0.82 for the pressure conduit distribution system and 1.13 for the canal distribution system.
7. *The benefit-cost ratios considering direct and indirect benefits and costs* are estimated to be as follows:

| Distribution System | Region | Province | Canada |
|---|---|---|---|
| Pressure Conduit | 1.15 | 1.25 | 1.54 |
| Canal | 1.65 | 1.80 | 2.26 |

These benefit-cost ratios are valid only if underutilized resources in the Canadian economy can be mobilized if the project is implemented. Given the economic conditions prevailing in 1982 and the persistently high levels of unemployment on the reserve, it is felt that the above benefit-cost ratios are a better indication of the economic viability of the project than the direct benefit-cost ratios.

8. A *sensitivity analysis* indicated that the most significant factors in determining the economic feasibility of the project are crop yields, crop prices and discount rates. Other variables such as energy costs, development rates, cropping patterns and construction costs are less significant but can still be very important.
9. The *distribution of benefits* among the three basic administrative districts is estimated as follows:

| | |
|---|---|
| Blood Indian Reserve | 40% |
| Province | 40% |
| Canada | 20% |

The distribution of benefits does not necessarily reflect the ability-to-pay; nor does it imply that the project would be financially feasible to any of the beneficiaries.

## C. Environmental Considerations

1. In general, *wildlife habitat* in the study area is poor because of adverse topography and aridity and because much of the land is under cultivation. The effects of the Mokowan Ridge Canal and Mokowan Reservoir on the natural environment are expected to be minimal.
2. *Drainage* of sloughs and wetlands would increase limitations to waterfowl production in an area where limitations are already severe. If drainage is routed to permanent or semi-permanent catchment ponds, the effects could be mitigated to some extent.
3. The buried pressure conduit *distribution system* would have less impact on the ecosystem than the canal distribution system, however, the impact of neither system is serious.
4. Proper *management of herbicides and pesticides* in the canals and on the irrigated area is essential to avoid deterioration in water quality in the St. Mary and Oldman rivers.
5. Soil salinity problems due to a rise in the water table would probably increase with sustained irrigation along the western margin of the Big Lease. A large area of the central and eastern part of the Big Lease would be irrigable without the possibility of a rise in the water table and accompanying soil salinity problems.

## D. Social Considerations

1. The 1979 *labor force* on the reserve was 1670 persons, of which 831 or 50 percent were employed. Demographic characteristics of the

reserve population indicate that the active labor force will increase to about 2600 persons by the year 1999. This will require the creation of about 75 new jobs per year.

2. *Employment opportunities* created by the project would be about 570 man-years of construction employment over the first 15 years of the project, about 60 man-years of farming and related secondary employment annually for the life of the project, and about nine man-years of employment annually for the operation and management of the water supply system. In the first 15 years, the project would create about 940 man-years of on-reserve employment for tribe members and would provide direct wages of about $16 million.

3. The *transition in lifestyle* required by tribe members to take advantage of employment opportunities could be made providing appropriate training programs were available. Agriculture is part of the cultural tradition of the Blood Tribe and is in tune with their attitudes toward using their sacred resources in perpetuity for the benefit of the tribe.

4. A reduction in the dependence of tribe members on *social assistance and preventative programs* would result from implementing the project. There would be a corresponding increase in individual initiative and self-esteem.

5. The *social impact of physical works* associated with the project would not appear to be a concern on the reserve.

## E. Administrative Considerations

1. Implementation of the project could be accompished by the use of a *three party agreement* between the Government of Canada, the Government of Alberta and an agricultural corporation of the tribal council covering financial, managerial and technical arrange-ments for construction, development and operation of the project. The tribal council should take the initiative toward negotiating this agreement.

2. A *tripartite managerial body* could be formed to control the project from a government perspective and to carry out the management functions performed by the Alberta Irrigation Council for off-reserve irrigation projects.

3. The formation of an *agricultural corporation* owned by the tribe will be required to act as the implementation agency for the tribe. This corporation would provide the management services usually performed by an irrigation district under the Alberta Irrigation Act and would negotiate and administer agreements with the farm operation units and with the agri-business community for joint ventures for growing specialty crops.

4. Initial irrigation blocks developed should be started up by the agricultural corporation and subsequently turned over to groups of fully trained operators who would form *farm operation units*. The long term objective would be the establishment of family farms.

5. A strong *vocational training program*, administered by the Blood Tribe would be required to provide a continuing supply of competent construction workers, farm workers and farm managers, if the tribe members are to take maximum advantage of opportunities presented by the project. This program would be implemented well in advance of construction of the project and integrated into an overall vocational training program on the reserve.

6. A total *development period* of 14 years is recommended, from the commencement of construction to the completion of the conversion of the target 25,000 acres from dryland agriculture to irrigated agriculture.

7. The tribe should initiate negotiations for *capital for the project* from:
   a) Alberta Department of Environment for headworks which could include the main canal and reservoir;
   b) Alberta Department of Agriculture and the Government of Canada on a cost-shared basis for the distribution system; and
   c) the Government of Canada on a cost-shared basis with the tribe for on-farm development costs.

8. An agreement to finance, construct and operate the project could be concluded within eighteen months of the release of this report.

## F. Discussion of Findings and Recommendations

The tripartite committee concludes that the *project is feasible* considering the technical, economic, environmental, social and administrative factors. Implementation of the project could be a positive step towards the betterment of the social and economic status of the tribe.

The investigations carried out in this study were tailored to satisfy the primary objective, namely, to determine the feasibility of irrigation on the Blood Indian Reserve. This objective has been met. In the next study phase, more detailed investigations will be required to select optimum design concepts for the project.

Two alternatives were considered for distributing the water to the Big Lease. The study revealed a decided economic advantage in the canal distribution system over the closed conduit system, however, the closed conduit system should not be ruled out on the basis of this analysis. Upon further study, design refinements may reduce the cost of the closed conduit system to the extent that, with due consideration of its many intangible benefits, it may prove to be the more practical alternative for this project. Furthermore, there are other design concepts and system layouts that should be considered prior to selecting specific conveyance, distribution and on-farm systems. While this study has established the feasibility of the project, more detailed engineering, agronomic and economic studies are required to optimize the design of the system. The tripartite committee recommends that these studies proceed immediately following an indication of agreement in principle to implement the project by the tribal council, the provincial government and the federal government.

If the tribal council decides to further pursue the project after it has carefully considered this report, it is recommended that the council prepare to initiate negotiations with the federal and provincial governments. The council could carry out a financial analysis of the project from the tribe's perspective and launch an information program on the reserve to determine the support of the tribal membership. Assuming favorable support of the membership, the tribal council should request an extension of the water right option for 25,000 acres of irrigation due to expire on April 1, 1984 and for a commitment in principle that the project will proceed. The parties could then prepare proposals for financing and administering the project for presentation to the federal and provincial governments.

The federal and provincial governments should review the study reports in detail in anticipation of receiving and responding to Blood Tribe proposals for implementing the project.

# Appendix A —
# Selected References


Agricultural Program Development Committee; *Blood Tribe Agricultural Development Program*; Blood Tribal Administration, Standoff; 1976.

Blood Tribal Council; *Brief to Environmental Council of Alberta*; Blood Tribal Administration, Standoff; November, 1978.

Blood Tribe Economic Development Department; *Blood Tribe Economic Development —Five Year Master Plan*; Blood Tribal Administration, Standoff; 1978.

Environment Council of Alberta; *Public Hearings on Management of Water Resources in the Oldman River Basin — Report and Recommendations*; ECA, Edmonton; 1979.

Gomez, K.A.; *On-Farm Assessment of Yield Constraints: Methodological Problems*; Article in: Constraints to High Yields on Asian Farms — An Interim Report; International Rice Research Institute, Manila; 1978.

Hart, J.R.; *Proposed Feasibility Study of Irrigation on the Blood Indian Reserve*; Alberta Environment, Calgary; April, 1981.

Marv Anderson and Associates; *Milk River Basin Studies: Socio-Economic Studies of Water Supply Alternatives - Part II*; Alberta Environment, Lethbridge; April 1981.

Marv Anderson and Associates; *Oldman River Basin Study Phase II: Economic Analysis of Water Supply Alternatives*; Alberta Environment, Lethbridge; April, 1978.

Oldman River Basin Study Management Committe; *Oldman River Basin Phase II Studies — Report and Recommendations*; Alberta Environment, Edmonton; August, 1978.

Water Resources Division; *Report on the Irrigated Land Classification for the Irrigation Council (Alberta Standards for Irrigated Land Classification*; Alberta Agriculture, Lethbridge; 1969.

# Appendix B — Membership of Committees

The organizational arrangements for carrying out the feasibility study are shown on Figure 2 of the main report. Membership of the various components of the organizational structure is listed below.

## 1. Blood Indian Irrigation Tripartite Committee

Representing the Blood Tribe:

Bernard Fox, Blood Tribe Administration (Co-Chairman)
Lester Tailfeathers, Tribe Councillor
Alec Hunt, Tribe Councillor
Camille Russell, Tribe Member

Past Members
Steven Fox, Former Tribe Councillor
Phillip Mistaken Chief, Former Tribe Councillor

Representing the Provincial Government:

Peter Melnychuk, Alberta Environment (Chairman)
Cy McAndrews, Alberta Agriculture (Executive Secretary)
Bill Calder, Federal and Intergovernmental Affairs
Ron Harrison, Alberta Native Affairs
Alternate — Don Shade, Alberta Native Affairs

Representing the Federal Government:

Gerry Steele, Canada Department of Indian Affairs and Northern Development
Lynn Hamilton, Canada Department of Indian Affairs and Northern Development
Reg Adam, Prairie Farm Rehabilitation Administration
Recording Secretary — Olive Bousquet, Alberta Agriculture

## 2. Implementation Sub-Committee

Bernard Fox, Chairman
Cy McAndrews, Alberta Agriculture
Doug Bouey, Walsh Young (legal council for the Blood Tribe)
Dick Hart, Alberta Environment
Doug Hagerman, Alberta Environment
Reg Adam, P.F.R.A.

## 3. Study Directorate

Dick Hart, Alberta Environment (Director)
Doug Bouey, Walsh Young (legal council for the Blood Tribe) (Co-Director)
Past Member, John Whitburn, Blood Tribe Administration

## 4. Technical Advisory Group

The first named under each component managed the component study. Others advised as required. The consultant(s) or study agency involved in each component is also named.

Mapping

— Ron Francis, Alberta Agriculture
— Art Potvin, Alberta Agriculture

Consultant: Brown Okamura and Associates Ltd.
Kenting Earth Sciences Ltd.
The Orthoshop

Land Classification

— Pano Karkanis, Alberta Agriculture

Consultant: Pedology Consultants

Agronomy

— Dick Heywood, Alberta Agriculture
— Len Ring, Alberta Agriculture

Consultant: Marv Anderson and Associates Ltd.

Engineering

— Ron Francis, Alberta Agriculture
— Wes Wankel, Alberta Agriculture

Study Agency: P.F.R.A.

Advisors: Walter Nemanishen
Erminio Caligiuri

Groundwater and Salinization

— Jim Hendry, Alberta Agriculture
— Brent Paterson, Albert Agriculture

Consultant: Simco Groundwater Research Ltd.

Economics

- Jim Barlishen, Alberta Environment
- Lynn Hamilton, DIAND
- Doug Hagerman, Alberta Environment
- Charlie Pei, Alberta Agriculture

Consultants: Underwood McLellan Ltd.
Marv Anderson and Associates Ltd.

Environment

- Brian Kemper, Alberta Environment

Consultant: International Environmental Consultants

Social

- Bernard Fox, Blood Tribe Administration
- Kerry Lowe, Alberta Environment
- Arnold Fox, Blood Band Administration
- Lorand Szojka, Alberta Environment

Consultants: P.M. Associates Ltd.

Implementation

- Implementation Sub-committee
- Training Program
    - Leonard Old Shoes, Blood Tribe Administration
    - Walter Nemanishen, P.F.R.A.
    - Gary Hartman, Alberta Agriculture
    - Camille Russell, Blood Tribe Administration

Consultant: Pratt Consulting Inc.

Synthesis and Reporting

- Dick Hart, Alberta Environment
- Doug Bouey, Walsh Young, Lawyers
- Elaine Dixson, Bureau of Public Affairs

Printer: Sundog Printing Services Ltd.

# Appendix C —
# Study Components

The study considered all factors which could affect the feasibility and implementation of an irrigation project on the Blood Indian Reserve; this required expertise in several areas. The following is a listing of the component studies and their objectives. The terms of reference for each component are set out in greater detail in the Proposed Feasibility Study of Irrigation on the Blood Indian Reserve (Hart; 1981)

### 1) Mapping

The objective of the mapping program was to provide topographical information for the land irrigability classification study and for the design and layout of a distribution system to serve the irrigation project.

### 2) Land Irrigability Classification

The land irrigability classification study was to provide a description of soil characteristics and properties, rate land units according to their suitability for sustained irrigation, identify potential soil problems that could be caused by irrigation, and recommend management techniques to maintain favourable soil characteristics under irrigation.

### 3) Agronomy

The agronomy component was conducted to determine the various crop types that could be grown, their respective yields and their water requirements considering topography, soil properties and climatic conditions in the study area. The most suitable method of irrigation was also to be determined.

### 4) Engineering

The objectives of the engineering component were to identify alternative water supply sources and determine their reliabilities, their storage requirements and diversion rates to provide preliminary designs and cost estimates for headworks and conveyance facilities from the water supply source (or alternative sources) to the block of irrigable land, to provide a preliminary layout and cost estimates for a distribution system to service the irrigable land, and to provide preliminary designs and cost estimates for drainage facilities to return excess water to the river systems.

### 5) Groundwater and Salinization

Large scale irrigation could induce high water table and salinity problems that could seriously reduce crop yields in or near the irrigated area. A groundwater and salinization study was required to identify and evaluate the potential adverse effects of irrigation on the soils and water table in and adjacent to the irrigation project. If potential problems were identified, the study was to recommend mitigative measures and preventative management practises.

### 6) Economics

The economics study was to estimate on-farm costs and benefits for various crop mix and irrigation method scenarios and provide an economic evaluation of the project considering alternative water supply possibilities, crop mixes, development rates, etc.

### 7) Environmental

The environmental component was to determine the environmental impact of the conveyance structures required to service the irrigation block and of irrigation farming itself. An environmental evaluation of various altneratives was to be provided.

### 8) Social

The objectives of the social component were to determine the social impact of structural works on claimed lands considering such factors as land uses, farming operations and severance of land; to determine the potential social benefits of the project considering factors such as jobs, income levels and lifestyle; and to determine social preferences for crop types and irrigation methods considering factors such as lifestyle, adapability to changes, training requirements, commitment to irrigation farming, etc. A public information program was to be carried out, and a social evaluation of various alternatives related to conveyance, crop types and irrigation methods was also to be provided.

### 9) Implementation Alternatives

The study of implementation alternatives was to identify and evaluate various financial and administrative options for developing the project.

### 10) Synthesis and Reporting

A report was to be prepared summarizing all component studies, evaluating alternatives and drawing conclusions.

# Appendix D — Metric-Imperial Unit Conversions

| | | |
|---|---|---|
| **Length** | | |
| 1 millimetre (mm) | = | 0.039 inches |
| 1 kilometre (km) | = | 0.621 miles |
| **Area** | | |
| 1 hectare (ha) | = | 2.471 acres |
| **Volume** | | |
| 1 cubic metre ($m^3$) | = | 35.314 cubic-feet |
| 1 cubic decametre ($dam^3$) | = | 0.811 acre-feet |
| **Rate of Flow** | | |
| 1 cubic metre per second ($m^3/s$) | = | 35.314 cubic feet per second |
| **Mass** | | |
| 1 tonne (t) | = | 1.102 tons |
| **Pressure** | | |
| 1 kilopascal (kPa) | = | 0.145 pounds per square inch |
| **Power** | | |
| 1 kilowatt (kW) | = | 1.341 horsepower |

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